HIRDLS

SP-HIR-064
LMMS # 1A25996

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: ERIC JOHNSON Date: 1998 11-20

Subject/Title: **HIRDLS Performance Verification Specification**

Description/Summary/Contents:

1. This document defines the technical requirements and verification approach which will be utilized on the HIRDLS program to demonstrate that the instrument meets requirements defined in SP-HIR-13R and is ready for radiometric calibration and flight operations. This document defines the performance and environmental parameters the instrument will be verified against.
2. This document satisfies the Instrument Integrator requirements of CDRL #L308

This version contains the comments derived from the CCB review process.
It is being submitted for signature and CCB approval.
Changes from the Draft Original submitted for CCB review
dated February 20, 1998 are indicated by change bars

Keywords: CDRL #L308, Testing, Requirements, Verification, ITS, VCRM

Purpose of this Document: Define the HIRDLS Program Verification Requirements
(20 char max.)

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Record of Revisions

Revision Letter	DESCRIPTION OF CHANGES	DATE
IR	**Original Document** Supersedes SP-LOC-085	98-11-20

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1.0 Background and Scope

1.1 Background

The High Resolution Dynamics Limb Sounder (HIRDLS) Program is an international joint venture between the US and the UK. Its purpose is to design, build, test, calibrate, launch, and operate a spaceborn spectral radiometer in the infra-red spectrum from 6-18 μm. The HIRDLS instrument is a scanning radiometer intended to map the earth's atmosphere from 8-80 kilometers altitude with an on-orbit absolute radiometric accuracy better than 1%. Each country is providing the resources necessary to perform the agreed upon tasks within the program. The UK is responsible for developing and testing the Structural Thermal Subsystem (STH), the Sunshield Subsystem(SSH), the Gyroscope Subsystem (GSS), the In-flight Calibrator (IFC) subsystem, and the Power Supply Subsystem (PSS). The UK is also responsible developing the warm and cold optical filters which reside within the Telescope and Detector Subsystems respectively and for performing the final radiometric calibration of the fully assembled, fully tested instrument prior to Spacecraft Integration and launch. The US is responsible for developing the Telescope Subsystem (TSS), the Detector Subsystem (DSS), the Instrument Processor Subsystem (IPS), and the Cooler Subsystem (CSS). The US is also responsible for performing the integration, verification, Line-of-Sight (LOS) calibration, and environmental testing of the instrument prior to radiometric calibration.

1.2 Scope

This document defines the technical requirements, verification parameters, and test sequence which shall be utilized on the HIRDLS program to demonstrate that the instrument meets the performance and environmental requirements defined in sections 3 and 4 of the Instrument Technical Specification (SP-HIR-13). This specification defines the method of verification which is to be used for each ITS requirement and the level of Instrument configuration under which each verification must occur. This is accomplished via the Verification Cross Reference Matrix (VCRM) defined in Table 4.2. This document also defines all the performance and environmental parameters the Proto-flight instrument is to be verified against and some of the performance and environmental parameters the Proto-flight subsystems are to be verified against. The scope of this document is confined to the verifications each Subsystem, the Instrument hardware, and flight software must undergo to satisfy the ITS line item requirements. It does not include the design specific verifications of individual subsystems, verifications of ground data processing, ground based operations software, Ground Support Equipment, or the radiometric calibration process.

1.3 Purpose

The purpose of this document is to define the minimum requirements for verification of the HIRDLS Instrument which when taken together will demonstrate Instrument performance and compliance to the Instrument requirements. Further, this document defines the environmental test parameters, the verification test sequence, and the number of times a given requirement must be verified for trending purposes.

1.4 Document Effectivity

This document becomes effective upon its formal release and supersedes all prior releases. Its effectiveness ceases upon the formal release of subsequent revisions.

2.0 Applicable Documents

The following Documents, of the exact issue shown, form a part of this specification to the extent specified herein.

2.1 Government Documents

SOW for HIRDLS Instrument Integration	PM-NCA-44	Nov. 11,1997
EOS Mission Assurance Requirement (DRAFT)	GSFC 424-11-13-01	Sept. '96
EOS Mission Assurance Requirements	GSFC 424-11-13-01	Oct. 96
HIRDLS Unique Instrument Interface Document	GSFC 424-28-21-06	dated
CDRL LIST	PM-NCA-41D	Nov. 8, 1996
Electromagnetic Interference Characteristics, Measurements of	MIL-STD-462C	dated

2.2 HIRDLS Program Documents

Instrument Technical Specification	SP-HIR-13, Rev. R	Sept. 10, 1997
HIRDLS Performance Verification Plan	TP-HIR-008C	May , 1998
HIRDLS Subsystem Environmental Requirements	SP-HIR-188	dated
HIRDLS Contamination Control Plan	PA-HIR-006	dated
HIRDLS Parts Control Plan	PA-LOC-203	
HIRDLS Instrument Test Plan	TP-LOC-204	dated

3.0 Instrument Overview

The HIRDLS PFM Instrument Layout is shown in Figure 3.0. The Instrument interfaces with the spacecraft mechanically, electrically, thermally, and optically as defined in the Unique Instrument Interface Document (GSFC 424-28-21-06). The HIRDLS Instrument, as defined in section 4 of the ITS, is comprised of nine distinct subsystems. As Instrument design has matured these nine subsystems have evolved into seventeen individual units or assemblies plus TBD interconnect cables. During Instrument Integration these subsystems shall be incrementally brought together and tested to ensure all mechanical, electrical, thermal, optical, and software interfaces function properly. Then the instrument shall undergo the instrument level testing required by this specification. The overall integration and verification philosophy which will be utilized on the HIRDLS program shall be defined in the HIRDLS Performance Verification Plan (TP-HIR-008) as required by CDRL #L022.

3.1 Instrument Requirements

The HIRDLS Instrument level requirements are defined in section 3 of the Instrument Technical Specification (ITS) SP-HIR-13. Subsystem specific requirements which flow directly from levels above the instrument (e.g. Radiometric Calibration, Flight Operations, etc.) are defined in section 4 of the ITS. Together sections 3 & 4 of the ITS define the whole of the Instrument requirements prior to Radiometric Calibration. The instrument mechanical envelope and interface to the spacecraft is defined in the HIRDLS Unique Instrument Interface Document (UIID), GSFC 424-28-21-06 (to be replaced by the Spacecraft to Instrument ICD when available). The Mission Assurance Requirements (MAR) document (GSFC 424-11-13-01) defines the safety and program assurance requirements which must be satisfied. The requirements in these three documents define the performance, inspection, and verification parameters which the instrument must be shown to satisfy.

3.2 Subsystem Descriptions

The following subparagraphs describe the nine subsystems which make up the HIRDLS instrument.

3.2.1 Structural/Thermal Subsystem (STH) Overview

The Structural/Thermal Subsystem serves two functions within the HIRDLS instrument. Its primary roll is to provide the mechanical interface between the Spacecraft and Instrument Subsystems. Its secondary roll is to provide the first level of stray light, thermal, and contamination control for the instrument subsystems. This subsystem is comprised of the Graphite Epoxy Main Structure, Fixed Sunshield, Passive Temperature Monitors and Survival Heaters, Interface Alignment Cube (IAC), and external multi-layer insulation (MLI) which surrounds the entire instrument. The Graphite Epoxy Main Structure provides the mechanical interface to the Spacecraft and structurally supports the subsystems. The Passive Temperature Monitors and Survival Heaters provide thermal monitoring and control during times when the instrument is powered and unpowered. The IAC provides the primary instrument optical reference during spacecraft integration. The fixed baffle augments the Main Aperture Door Assembly within the SSH in preventing direct sunlight from entering the instrument during low sun angle orbit conditions. Finally, the MLI provides the first level of thermal isolation.

3.2.2 Sunshield Subsystem (SSH) Overview

The Sunshield Subsystem consists of the Main Aperture Door Assembly, the fixed baffle, and the Space Reference View Door Assembly. The Main Aperture Door Assembly contains a position controlled door which is actuated during operation to prevent direct sunlight from entering the instrument viewing aperture, Sun sensors which are placed around the aperture to provide a back-up command signal should the viewing aperture become inadvertently pointed at the sun, and a Door Latch Mechanism which secures the door during environmental testing and launch. The Space Reference View aperture door contains the door drive mechanism, door, baffle tube (TBV), and Albedo Shield. This mechanism serves as a contamination cover during ground operations and launch and as a stray light baffle.

3.2.3 Gyro Subsystem (GSS) Overview

The Gyro Subsystem (GSS) is a strapdown inertial reference unit which is comprised of the Gyro Mechanical Unit (GMU) and the Gyro Electronics Unit (GEU). The GMU contains four single axis rate integrating iron gyros each of which measures rotation about its input axis relative to inertial space. The GMU mechanically mounts to the SSG Assembly OBA and provides the data necessary to “anchor” the instrument LOS to the inertial reference frame. The GEU contains all the electronics necessary to operate and control the GMU and provides the command and data interface to the IPU. The GEU mounts to the underside of the STH shelf as shown in Figure 3.0.

3.2.4 Telescope Subsystem (TSS) Overview

The Telescope Subsystem is the heart of the HIRDLS instrument as it encompasses the majority of the Instrument radiometric and LOS requirements. The Telescope Subsystem has been separated into five distinct elements, each having its own specification consistent with the disciplines for each element.

SSG Assembly:

The first element is the SSG Assembly which is comprised of three separate assemblies:

Optical Bench Assembly (OBA):

The primary element of the SSGA is the Optical Bench Assembly. The OBA contains the Optical Bench structure, Scan Mirror (S/M), Primary Mirror, Secondary Mirror, Calibration Mirror, Space View Relay Mirror, Fold Mirror, two Germanium Lenses, Stops, “Hot Dog” Aperture, and Baffles. The OBA also serves as the mounting base for the Chopper Mechanical Unit (CMU), Accelerometers, In-flight Calibrator Black Body (IFCBB), Gyro Mechanical Unit (GMU), Warm Filter Carrier, and Detector Subsystem (DSS). The OBA has four optical paths: the primary path which views the atmosphere during operation, the Calibration Path which views the IFCBB, and the Space Reference View which views deep space off the chopper, and the radiation trap view which absorbs the incoming radiation from the primary path off the back surface of the chopper when the chopper is closed (detectors are viewing the Space Reference View path).

Encoder Electronics Assembly (EEA):

The second of the three assemblies making up the SSGA is the Scan Mirror Encoder Electronics Assembly. The EEA contains all the processing electronics to convert the analog output of the two Elevation Encoder heads and one Azimuth Encoder head into digital position information.

Wobble Sensor Electronics Assembly:

The third assembly within the SSGA is the Wobble Sensor Electronics Assembly. The WSEA contains the compensation and buffering electronics for the Scan Mirror Azimuth bearing Wobble Sensors as well as the cables between the OBA and the Wobble Sensor Electronics Assembly.

TEU:

The second element of the TSS is the Telescope Electronics Unit (TEU). The TEU contains the interface to read the Scan Mirror encoder position from the EEA, read the Accelerometers, and command the Scan Mirror. It also contains control algorithms for the Scan Mirror, including the feedforward algorithms, the Chopper control electronics, and the command interface with the Instrument Processor Unit (IPU). The Accelerometers measure base motion of the OBA and provide the vibration input to the feed forward control system. Both the Chopper Mechanical Unit and Accelerometers mount directly onto the OBA.

Chopper Mechanical Unit:

The third element of the TSS is the Chopper Mechanical Unit. The Chopper Mechanical Unit contains the chopper motor, bearings, blade, light trap, and blade position sensing optical diodes.

Optical Bench Vibration Isolators:

The fourth element of the TSS is the Optical Bench Vibration Isolators. The Optical Bench Vibration Isolators mount between the STH and OBA and are used to isolate the OBA from the on-orbit operational vibration of the Spacecraft at frequencies above 50 Hz.

Accelerometers:

The fifth element of the TSS are the Accelerometers. The accelerometers are used to detect the vibrational base motion of the Optical Bench Assembly and form the input to the base motion Feedforward control system.

3.2.5 Detector Subsystem (DSS) Overview

The Detector Subsystem contains all the detectors which sense the infra-red radiation emitted from the atmosphere. It contains the 21 HgCdTe detectors which sense the infra-red radiation contained within the 21 atmospheric radiation bands of scientific interest (6μm to 18μm). The DSS also contains a 22nd detector which is comprised of 4 HgCdTe detectors arranged as a quadrant detector. This detector is utilized only during ground based LOS and instrument focus testing. The 22 detectors are housed within a vacuum dewar and cooled, by the Cooler Subsystem, to 60K - 65K. The DSS provides the mechanical, optical, and thermal interface for the Cold Filter Assembly; it has a mechanical and optical interface to the TSS Optical Bench Assembly and a mechanical and thermal interface with the Cooler Mechanical Unit Cold Link. It electrically interfaces with the Signal Processor Unit, part of the IPS, at the output of each detector.

3.2.6 In-flight Calibrator (IFC) Overview

The In-flight Calibrator (IFC) provides the high temperature (approx. 300K) reference signal required for in flight calibration of the HIRDLS instrument. It is comprised of the IFC Black-body (IFC BB), the Black-body Electronics Unit (BEU), and the cable which goes between the IFCBB and the BEU. The IFC Black-body is thermally controlled and monitored very accurately. It mounts within the SSG Assembly OBA and is optically linked to the system by the Calibration Mirror. The BEU contains the control and monitor electronics necessary to maintain the IFC BB at its required temperature and provides the electrical interface between the IFC BB and the IPU. The BEU mounts to the STH within the same cavity as the OBA.

3.2.7 Instrument Processor Subsystem (IPS) Overview

The Instrument Processor Subsystem (IPS) manages the Instrument side of the Instrument/Spacecraft command and telemetry interface and provides the centralized communications, data processing, timing, temperature control, and housekeeping services within the HIRDLS instrument. It is comprised of the Instrument Processor Unit (IPU), the Signal Processing Unit (SPU), and nearly all the interconnect cables within the instrument. The IPU contains the microprocessors and control electronics required to operate each element of the instrument and interface with the Spacecraft command and telemetry system. The SPU is the principal interface to the DSS. It contains the detector pre-amplifiers, filters, and A/D converters necessary to convert the analog detector signals into digital telemetry counts. The IPU mounts to the STH Baseplate within the electronics unit cavity (as shown in Figure 3.0) and the SPU mounts to the STH in the same cavity as the OBA.

3.2.8 Cooler Subsystem (CSS) Overview

The Cooler Subsystem is a thermal-mechanical device, a refrigerator, designed to cool the DSS to the 60K cryogenic temperature required for operation. The CSS is comprised of three distinct units: the Cooler Control Unit (CCU), the Cooler Mechanical Unit (CMU), and the Cooler Radiator Panel. The CCU contains the control electronics for the cooler and provides the electrical interface to the Instrument Processor Unit (IPU) and the Power Converter Unit (PCU). The CMU is comprised of the Compressor Unit, Displacer Unit, Cold Link, and Flex Housing. The Cooler Radiator panel serves as the mechanical interface between the CMU and the STH and is the primary thermal interface transferring the heat generated by the Compressor and Displacer out of the instrument. The Cooler Radiator Panel also provides the structural mounting interface to the Space View Aperture Door mechanism of the SSH.

3.2.9 Power Supply Subsystem (PSS) Overview

The Power Supply Subsystem (PSS) is totally comprised of the Power Converter Unit (PCU). As such, the term PSS and PCU can be, and often are, used interchangeably. The PCU takes the spacecraft generated power from the quiet and noisy buses of the S/C, through the S/C Interface Panel, performs the quiet bus power conversion, the switching, and the rerouting to each required subsystem. It also performs the Noisy Bus switching required by the CSS but does not perform any conversion. All Noisy Bus power conversion is handled within the CSS as it is the sole user of Noisy Bus power.

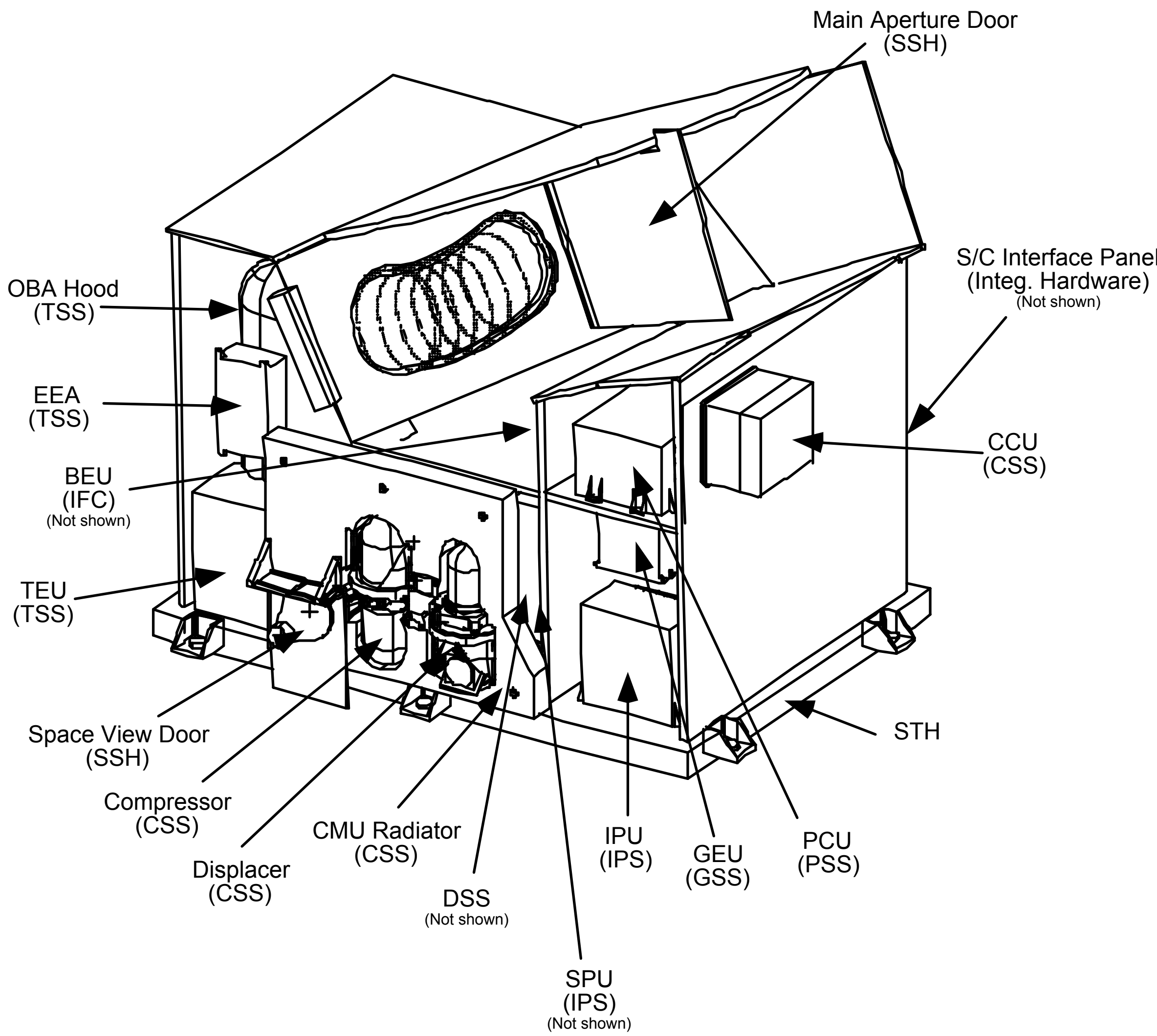


Figure 3.0
Instrument Layout

4.0 Quality Assurance Provisions

4.1 General.

Quality Assurance provisions for the HIRDLS instrument shall be as specified herein and in accordance with the MAR (GSFC 424-11-13-01). Certain quality assurances are required to support the reliability of the instrument operating for an extended time in a space environment. Qualification and acceptance testing of the HIRDLS instrument shall be combined into a single test program entitled Proto-flight Tests (Section 4.3). The instrument shall be considered ready for flight upon successful completion of inspection, analysis, tests, and demonstrations as specified in this document.

4.1.1 Responsibility for Tests.

Unless otherwise specified, Instrument level testing shall be conducted at the Instrument Integrators facility in accordance with the approved PFM Instrument Test Plan (TP-LOC-204) and Acceptance Test Procedures. The Instrument Integrator shall be responsible for designing and performing all Proto-flight tests on the Instrument. Subsystem level testing shall be conducted at each Subsystem Responsible Organization (RO) facility in accordance with Subsystem specific Test Plans and Acceptance Procedures.

4.1.2 Special Tests and Examinations.

4.1.2.1 Components and Subsystems.

Prior to Instrument assembly, all active parts, subassemblies, assemblies, units, and subsystems shall be inspected, tested, and accepted in accordance with their respective specifications or drawings. Selection of any new parts, subassemblies, assemblies, units, or subsystems shall also necessitate inspection and acceptance in accordance with their specifications and drawings.

4.1.2.2 Environmental Stress Screening.

The purpose of Environmental Stress Screening is to stress the hardware to identify failed and weak parts and workmanship defects. Environmental stress screening shall be performed in accordance with the HIRDLS Parts Control Plan (PA-LOC-203) at the part, subassembly, unit, or subsystem level as deemed appropriate and with the approval of the HIRDLS program office.

4.1.2.3 Engineering Development Tests and Evaluations

Measurements, tests and evaluations shall be used for obtaining design parameters and for confirming that the instrument will meet the performance and safety requirements specified in the Instrument Technical Specification (SP-HIR-13) before Proto-flight testing. Instrument level testing deemed appropriate for this level shall be performed on the Engineering Model as defined in the HIRDLS Performance Verification Plan (TP-HIR-008).

4.2 Quality Conformance

The verification of the HIRDLS instrument performance against the requirements delineated in the Instrument Technical Specification (ITS) will be performed throughout the course of the program. Complete verification of the HIRDLS instrument against its requirements will occur through a combination of the four independent verification methods defined below.

The method which shall be used for the verification of each ITS requirement is defined in Table 4.2 the Verification Cross Reference Matrix (VCRM).

4.2.1 Methods and Levels of Verification

The requirements defined in the ITS shall be verified by the methods and at the configuration levels defined in Table 4.2. The following subparagraphs define the terms used to describe each of the methods of verification and each of the configuration levels. Formal verification testing (Proto-flight tests) shall be performed in accordance with section 4.3 of this document.

4.2.1.1 Inspection (I)

This method involves examining an item against the applicable documentation to confirm compliance with the requirements. This method also involves physically examining the article to ensure conformance with envelope, mass, and electrical grounding requirements.

4.2.1.2 Analysis (A)

This method consists of interpreting or interpolating/extrapolating analytical or empirical data with reference to defined conditions or analytical procedures to ascertain theoretical compliance with stated requirements.

4.2.1.3 Test (T)

This method entails performance of a functional operation under specific conditions. Instrumentation and special test equipment, or both, shall be used to generate, acquire, and record data. This method shall also include analysis of test data.

4.2.1.4 Demonstration (D)

This method of verification involves performance of a functional operation under specific conditions in a Pass/Fail scenario. Instrumentation and special test equipment, or both may be used to generate, acquire, and record data which will be used to determine if the instrument performance lies within the required range.

4.2.1.5 Not Applicable (N)

Use of the term "not applicable" shall be limited to those paragraphs/paragraph headings for which there is no method of verification or where verification is specified in subparagraphs.

4.2.1.6 Level

The term "level" in the context of verification refers to the level of assembly the hardware or software will be at when the particular requirement is verified. The following subparagraphs define the various levels.

4.2.1.6.1 Instrument (Inst.):

A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, the HIRDLS Instrument is defined to be the point were all nine subsystems are fully integrated.

4.2.1.6.2 Instrument Integration (I/I):

A functional subdivision of the instrument which is comprised of two or more subsystems, units from different subsystems, or any combination thereof but does not include all instrument subsystems. Examples of verifications at the Instrument Integration level are subsystem-to-subsystem interface testing, optical alignments, etc.

4.2.1.6.3 Subsystem (S/S):

A functional subdivision of the Instrument. The HIRDLS Instrument has nine subsystems as defined in section 3.2.

4.2.1.6.4 Unit:

A functional subdivision of a subsystem, and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are the Telescope Electronics Unit, Blackbody Electronics Unit, Encoder Electronics Assembly, etc.

4.2.1.6.5 Assembly (Assem):

A functional subdivision of a Unit consisting of parts or subassemblies that perform functions necessary for the operation of the Unit as a whole. Examples the Encoder Heads, single axis Gyro, etc.

4.2.1.6.6 Subassembly (S/A):

A subdivision of an assembly or Unit. Examples are wire harness and loaded printed circuit boards.

4.2.1.6.7 Part:

A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	Paragraph Title	I	A	T	D	N	Level
3.0	Instrument Specification					N	
3.1	Inst. Description and Definition					N	
3.1.3	Coordinate Frames					N	
3.1.3.1	Space Reference Coordinate Frame					N	
3.1.3.2	Instrument Ref. Coordinate Frame	I					
3.1.3.3	Telescope Ref. Coordinate Frame					N	
3.2	Modes of Operation					N	
3.2.1	Off Mode			T			Inst.
3.2.2	Survival Mode			T			Inst.
3.2.3	Idle Mode			T			Inst.
3.2.4	Low Power Mode			T			Inst.
3.2.5	Standby 1 Mode			T			Inst.
3.2.6	Standby 2 Mode			T			Inst.
3.2.7	Mission Mode			T			Inst.
3.3	Optical Specifications					N	
3.3.1	Vertical Field of View			T			Inst.
3.3.2	Vertical Response			T			Inst.
3.3.3	Vertical Response Stability					N	

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
3.3.3.1	Within a Single Channel		A				Inst.
3.3.3.2	Between Channels		A				Inst.
3.3.4	Horizontal Field of View			T			Inst.
3.3.5	Out-of-Field Response			T			Inst.
3.3.6	Focus					N	
3.3.6.1	Object Distance			T			Inst.
3.3.6.2	Active Focusing	I					
3.3.7	Obscurations		A				Inst.
3.4	Radiometric Specifications					N	
3.4.1	Channel Spectral Response		A				Inst.
3.4.2	Spectral Response Stability		A				Inst.
3.4.3	Out-of-Band Response		A				Inst.
3.4.4	Radiometric Performance					N	
3.4.4.2	Radiometric Channel Gain			T			I/I
3.4.4.2.1	Radiometric Channel Gain Stability		A				Inst.
3.4.4.3	Radiometric Channel Offset				D		Inst.
3.4.4.3.1	Radiometric Channel Offset Stability		A				Inst.
3.4.4.4	End-to-End Channel Transfer Funct.			T			Inst.
3.4.4.5	Elect. Crosstalk bet. Radiometric Channels			T			S/S
3.4.4.5.1	Elect. Crosstalk under Test Overload			T			S/S
3.4.4.6	Radiometric Channel Overload Recovery			T			I/I
3.4.4.7	Radiometric Channel Slew Rate			T			S/S
3.4.5	Radiometric Noise			T			Inst.
3.4.6	Dynamic Range			T			Inst.
3.4.7	Radiometric Digitization					N	
3.4.7.1	Radiometric Quantization Error			T			S/S
3.4.7.2	Radiometric Quantization Step Size Uniformity			T			S/S
3.4.7.3	Sampling Rates					N	
3.4.7.3.1	Raw Data Sampling Rate	I					I/I
3.4.7.3.2	Radiometric Sampling Rate	I			D		I/I
3.4.8	Radiometric Signal Processing	I					S/S
3.4.8.1	Spatial Resolution and Noise Rejection			T			S/S
3.4.9	In-flight Radiometric Calibration	I					Inst.
3.5	Pointing and Scanning Specifications	I					Inst.
3.5.1	Elevation Pointing and Scanning					N	
3.5.1.1	Elevation Scan Range			T			Inst.
3.5.1.2	Elevation Scan Rate		A	T	D		Inst.
3.5.1.4	Fixed Angle Mode	I		T	D		Inst
3.5.1.5	Elevation Angle Jitter		A	T			Inst
3.5.2	Azimuth Pointing and Scanning					N	
3.5.2.1	Azimuth Scan Range			T			Inst.
3.5.2.2	Azimuth Scan Step and Settle			T			S/S

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
3.5.2.3	Azimuth Pointing Accuracy		A	T			Inst.
3.5.3	Instrument Alignment					N	
3.5.3.1	Interface Alignment Cube	I					Inst.
3.5.3.2	TRCF-to-IRCF Alignment		I	T			
3.5.3.3	Optical Cube Requirements	I					S/S
3.5.3.3.1	Optical Cube Surface Area	I					S/S
3.5.3.3.2	Optical Cube Surface Orthogonality	I					S/S
3.5.3.3.3	Optical Cube Documentation	I					S/S
3.5.3.3.4	Optical Cube Cover	I					S/S
3.6	Mechanical Specifications					N	
3.6.1	Instrument Envelope	I					Inst.
3.6.2	Instrument Mass Properties					N	
3.6.2.1	Mass	I					Inst.
3.6.2.2	Center of Mass Measurement	I					Inst.
3.6.2.3	Moments of Inertia		A				Inst.
3.6.3	Mechanical Interface with Spacecraft					N	
3.6.3.1	Instrument Mounting	I					Inst.
3.6.3.1.1	Mounting Interface	I	A				Inst.
3.6.3.1.2	Instrument Drill Templates	I					S/S
3.6.3.2	Limit Loads		A				Inst.
3.6.3.2.1	Factors of Safety		A				Inst.
3.6.3.2.2	Qualification Loads		A				Inst.
3.6.3.2.3	Strength of Materials		A				Inst.
3.6.3.3	Disturbance Torques		A				Inst.
3.6.4	Instrument Structural Dynamics		A				Inst.
3.6.5	Pressurized System Design		A	T			S/S
3.6.6	Instrument Mechanisms					N	
3.6.6.2	Caging of Mechanisms	I					Inst.
3.6.6.3	Drive Mechanism Torque Margin		A				S/S
3.6.6.4	Drive Motor Locked-Rotor Survival	I	A	T			Inst.
3.6.7	Access to Instrument Components	I					Inst
3.6.9	Launch Site Equipment Installation and Removal	I					Inst
3.7	Electrical Specifications					N	
3.7.1	Electrical Interface with Spacecraft	I	A	T			I/I
3.7.1.1	Power Buses				D		I/I
3.7.1.1.1	Quiet Power Bus			T			I/I
3.7.1.1.2	Noisy Power Bus			T			I/I
3.7.1.1.3	Survival Heater Power Bus			T			I/I
3.7.2	Power Specification					N	
3.7.2.3	Input Voltage					N	
3.7.2.4	Input Voltage Ripple				D		I/I
3.7.2.5	Impedance					N	

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
3.7.2.6	Abnormal Operation					N	
3.7.2.6.a	Unannounced Power Removal		A				Inst
3.7.2.6.b	Polarity Reversal		A				Inst
3.7.2.6.c	Loss of One Side of Power Supply		A				Inst
3.7.2.6.d	Overvoltage		A				Inst
3.7.2.7	Current					N	
3.7.2.7.1	Transients				D		I/I
3.7.2.7.2	Current Ripple				D		I/I
3.7.2.7.3	Overcurrent Protection	I	A				Inst.
3.7.3	Grounding & Isolation					N	
3.7.3.1	Chassis Ground	I					Inst.
3.7.3.2	Primary Power Isolation			T			I/I
3.7.3.3	Secondary Power Isolation	I		T			I/I
3.7.3.4	Connector Grounding	I					Inst.
3.7.3.5	Thermal Blanket Grounding	I		T			I/I
3.7.3.6	Bonding			T			I/I
3.7.3.6.1	Equipment Bonding	I					Inst.
3.7.3.6.2	Electrical Connector Bonding			T			I/I
3.7.4	Power Leads and Returns	I					I/I
3.7.4.1	Primary Power	I			D		I/I
3.7.4.2	Secondary Power	I			D		I/I
3.7.5	Connectors	I					Inst.
3.7.5.1	Connector Clearance	I					I/I
3.7.5.2	Keying	I					Inst.
3.7.5.3	Connector Types	I					Inst.
3.7.5.4	Protective Covers	I					Inst.
3.7.5.5	Connector Savers	I					I/I
3.7.5.6	Electrical Connector Constraints	I					I/I
3.7.5.7	Connector Position	I					Inst.
3.7.6	EMI/EMC					N	
3.7.6.1	Conducted Emission, Power Leads (CE01/CE03)			T			Inst.
3.7.6.2	Conducted Susceptibility, Power Leads (CS01/CS02)			T			Inst.
3.7.6.3	Conducted Susceptibility, Spike, Power Leads (CS06)			T			Inst.
3.7.6.4	Radiated Emission, Magnetic Field					N	
3.7.6.4.1	Radiated AC Magnetic Field Emissions (RE01/RE04)			T			Inst.
3.7.6.4.2	Radiated DC Magnetic Field Emissions			T			Inst.
3.7.6.4.3	Magnetic Fields Documentation	I					Inst.
3.7.6.5	Narrowband Emission, Electric Field (RE02)			T			Inst.
3.7.6.6	Broadband Emission, Electric Field (RE02)			T			Inst.
3.7.6.7	Radiated AC Magnetic Field Susceptibility (RS01)			T			Inst.

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
3.7.6.8	Radiated DC Magnetic Field Susceptibility			T			Inst.
3.7.6.9	Radiated Susceptibility, Electric Field (RS03)			T			Inst.
3.7.7	Temperature Sensors	I					Inst.
3.7.8	Survival Heaters	I	A	T			Inst.
3.8	Thermal Specifications					N	
3.8.1	Thermal Interface with Spacecraft		A	T			Inst.
3.8.1.1	Thermal Design		A	T			Inst.
3.8.1.2	Heat Transfer		A	T			Inst.
3.8.2	Instrument Temperatures		A	T			Inst.
3.8.3	Thermal Control Hardware					N	
3.8.3.1	Thermal Control Hardware Responsibility	I					Inst.
3.8.3.2	Cooler Make-up Heaters	I		T			Inst.
3.9	Command and Data Handling Specifications	I	A	T	D		S/S
3.9.1	Passive Analog Telemetry	I					Inst.
3.9.3	Command and Telemetry (C&T) Bus Specification					N	
3.9.3.1	Digital Data Convention	I			D		S/S
3.9.3.2	C&T Bus Functions				D		S/S
3.9.3.3	C&T Bus Type and Configuration	I		T	D		S/S
3.9.3.4	General C&T Bus Specifications					N	
3.9.3.4.1	C&T Bus Electrical Interface	I	A				Inst.
3.9.3.4.2	General C&T Bus Protocol	I		T			S/S
3.9.3.5	Command Protocol Specifications				D		S/S
3.9.3.5.1	Command and Memory Load Packet Formats	I			D		S/S
3.9.3.5.2	Command Constraints				D		S/S
3.9.3.5.3	Illegal Command Monitoring	I			D		S/S
3.9.3.5.4	Time Marks and Time Code Data	I			D		S/S
3.9.3.6	Telemetry Protocol Specifications	I			D		S/S
3.9.3.6.1	Engineering Telemetry	I			D		Inst.
3.9.3.6.2	Science Telemetry				D		Inst.
3.9.3.6.3	Diagnostic Telemetry	I					Inst.
3.9.3.6.4	Instrument to Spacecraft Transmission Time-outs				D		S/S
3.10	Software Specifications					N	
3.10.1	Software Language Requirements	I					Inst.
3.10.2	Flight Software Requirements	I			D		Inst.
3.10.2.1	Software Development Requirements	I					Inst.
3.10.2.4	Flight Software Version Control	I					Inst.
3.10.2.5	Flight Software On-Orbit Installation and Verif.	I			D		Inst.
3.10.2.6	Processor System Resource Utilization	I					Inst.
3.10.3	Flight Software Development Environment	I					Inst.
3.11	Environments		A				Inst.
3.11.1	Random Vibration			T			Inst.
3.11.2	Sine Vibration			T			Inst.

ITS Para #	Verification Cross Reference Matrix Paragraph Title	I	A	T	D	N	Level
3.11.3	Acceleration			T			Inst.
3.11.4	Shock		A				Inst.
3.11.5	Acoustic		A				Inst.
3.11.6	Thermal Environments		A	T			Inst.
3.11.7	On-Orbit Vibration Environment		A	T			Inst.
3.11.8	Humidity		A		D		Inst.
3.11.9	Pressure		A	T			Inst.
3.11.10	Radiation					N	
3.11.10.1	Total Ionizing Dose Radiation Environment		A				Inst.
3.11.10.2	Cosmic Ray and High Energy Proton Environment		A				Inst.
3.11.10.3	Spacecraft Charging		A				Inst.
3.11.11	Atomic Oxygen		A				Inst.
3.11.12	Storage, Handling, and Transportation	I					Inst.
3.12	Contamination Control Requirements					N	
3.12.1	Materials Selection Criteria	I					Inst.
3.12.1.1	Acceptance Screening of Nonmetallics		A				Inst.
3.12.1.2	Outgassing of Materials and Subsystems		A	T			Inst.
3.12.1.3	Settled Particulate Distributions	I					Inst.
3.12.2	Baseline Requirements for HIRDLS Contam. Control					N	
3.12.2.1	Settled Particulates	I	A				Inst.
3.12.2.2	Molecular Contaminants	I	A				Inst.
3.12.3	Contamination Control Through Design	I					Inst.
3.12.3.1	Instrument Venting					N	
3.12.3.1.1	Closure and Venting for Launch	I					Inst.
3.12.3.1.2	Outward Venting	I					Inst.
3.12.3.1.3	Inward Venting		A				Inst.
3.12.4	Sources of Contamination					N	
3.12.4.1	Internal		A				Inst.
3.12.4.2	External		A				Inst.
3.12.4.3	Impact of HIRDLS Emissions on Other Instruments	I					Inst.
3.12.5	Verification of Cleanliness Levels	I	A				Inst.
3.12.6	Protective Measurements to Maintain Cleanliness	I					Inst.
3.13	Reliability and Safety Specifications	I	A				Inst.
3.13.1	Instrument Reliability Level		A				Inst.
3.13.2	Operational Life		A				Inst.
3.13.3	Storage Life		A				Inst.
3.14	Quality Assurance Requirements	I					Inst.
3.14.1	Identification and Markings	I					Inst.
3.14.2	Configuration Control	I					Inst.
3.14.3	Procurement Control	I					Inst.
3.14.4	Fabrication Control	I					Inst.

ITS Para #	Paragraph Title	I	A	T	D	N	Level
	Verification Cross Reference Matrix	**Method of Verification**					
3.14.4.1	Electrostatic Discharge Control	I					Inst.
3.15	Instrument Operational Concepts					N	
3.15.1	Instrument Commanding Philosophy	I	A				Inst.
3.15.2	Instrument Monitoring and Safing Philosophy	I	A				Inst.
3.16	Safety Requirements	I					Inst.
3.16.1	Structural Integrity and Fracture Control		A	T			Inst.
3.17	Design and Construction Requirements	I					Inst.
3.17.1	Use of Metric Components	I					Inst.
3.17.2	Parts	I					Inst.
3.17.3	Materials and Processes	I					Inst.
3.18	Performance Verification Requirements	I					Inst.
3.19	Documentation Requirements					N	
3.19.1	Use of Systeme International (SI) Units	I					Inst.
3.19.2	Instrument Interface Control Drawing Requirements	I					Inst.
3.19.3	Internal Interface Control Document Requirements	I					Inst.
3.19.4	Data Interface Documentation Requirements	I					Inst.
4	**Subsystem Requirements**					N	
4.1	**Structure/Thermal Subsystem**					N	
4.1.1	Subsystem Description						S/S
4.1.2	Modes of Operation						S/S
4.1.3	Mechanical Requirements					N	
4.1.3.1	Structure/Thermal Subsystem Envelope	I					S/S
4.1.3.2	Mass			T			S/S
4.1.3.3	Lifting Points	I					S/S
4.1.3.4	De-Pressurization and Venting	I	A				S/S
4.1.3.5	Access	I					S/S
4.1.3.6	Mechanical Performance		A	T			S/S
4.1.3.7	Mechanical Interfaces	I					S/S
4.1.4	Electrical Requirements					N	
4.1.4.1	Input Power Requirements					N	
4.1.4.1.1	Power Allocation						
4.1.4.1.2	Primary Power						
4.1.4.1.3	Secondary Power	I					S/S
4.1.4.2	Grounding Requirements	I					S/S
4.1.4.2.1	Primary Power Grounding	I		T			S/S
4.1.4.2.2	Secondary Power Grounding					N	
4.1.4.3	Electrical Interfaces	I					S/S
4.1.5	Thermal Requirements					N	
4.1.5.1	Survival Heaters	I		T			S/S
4.1.5.2	Thermal Blankets	I	A				S/S
4.1.5.3	Radiators						
4.1.5.3.1	Temperature Variation at Unit Mounting Faces		A	T			S/S

ITS Para #	Verification Cross Reference Matrix Paragraph Title	I	A	T	D	N	Level
4.1.5.3.2	Accommodation for Laboratory Cooling						
4.1.5.4	Thermal Interfaces	I	A				S/S
4.1.6	Environments		A				S/S
4.1.7	Reliability Requirements		A				S/S
4.2	**Sunshield Subsystem**					N	
4.2.1	Subsystem Description					N	
4.2.2	Modes of Operation						
4.2.3	Functional Requirements					N	
4.2.3.1	Closure and Shielding	I	A				S/S
4.2.3.2	Drive Mechanisms			T			S/S
4.2.3.3	Angle Sensors			T			S/S
4.2.3.4	Hold-down and Release Mechanism		A	T			S/S
4.2.3.4.1	Latching Without Power	I					S/S
4.2.3.4.2	Latching Status			T			S/S
4.2.3.5	Sun Sensors						
4.2.3.6	Fixed Baffles	I					S/S
4.2.4	Mechanical Requirements	I					S/S
4.2.4.1	Envelope	I					S/S
4.2.4.2	Mass Properties	I					S/S
4.2.4.3	Mechanical Performance		A				S/S
4.2.4.3.2	Door Motion Disturbances		A				S/S
4.2.4.4	Mechanical Interfaces	I					S/S
4.2.5	Electrical Requirements	I					S/S
4.2.5.1	Input Power Requirements					N	
4.2.5.1.1	Primary Power					N	
4.2.5.1.2	Secondary Power	I		T			S/S
4.2.5.2	Grounding Requirements					N	
4.2.5.2.1	Primary Power Grounding					N	
4.2.5.2.2	Secondary Power Grounding	I		T			S/S
4.2.5.3	Electrical Interfaces	I					S/S
4.2.5.4	Electromagnetic Disturbances			T			S/S
4.2.6	Thermal Interfaces	I					S/S
4.2.7	Environments		A	T			S/S
4.2.8	Reliability Requirements		A				S/S
4.3	**Gyro Subsystem**					N	-
4.3.1	Subsystem Description	I					SS
4.3.2	Modes of Operation				D		SS
4.3.3	Performance Requirements			T			SS
4.3.3.1	Digital Rate Output			T			SS
4.3.3.2	Angular Measurement Requirements		A	T			SS
4.3.3.2.1	Elevation Requirements		A	T			SS
4.3.3.2.2	Azimuth Requirements		A	T			SS

(Column group I–N and Level: Method of Verification)

ITS Para #	Verification Cross Reference Matrix Paragraph Title	Method of Verification I	A	T	D	N	Level
4.3.3.3	Survival Rates			T			SS
4.3.3.4	Warm-up			T			SS
4.3.4	Mechanical Requirements					N	-
4.3.4.1	Gyro Subsystem Envelope	I					U
4.3.4.2	Mass Allocation	I					U
4.3.4.3	GMU-GEU Interconnection				D		A
4.3.4.4	Alignment					N	-
4.3.4.4.1	Optical Alignment Cube					N	-
4.3.4.5	Mechanical Interfaces	I					U
4.3.4.6	Pressurization and Venting	I	A				SA
4.3.5	Electrical Requirements					N	-
4.3.5.1	Input Power Requirements			T			SS
4.3.5.1.1	Primary Power					N	-
4.3.5.1.2	Secondary Power					N	-
4.3.5.2	Grounding Requirements					N	-
4.3.5.2.1	Primary Power Grounding	I					SS
4.3.5.2.2	Secondary Power Grounding	I					SS
4.3.5.3	EMI/EMC Requirements			T			SS
4.3.5.4	Electrical Interfaces			T			SS
4.3.6	Thermal Requirements					N	-
4.3.6.1	Subsystem Temperatures			T			SS
4.3.6.2	Thermal Interfaces					N	-
4.3.6.2.1	GMU Thermal Interface		A	T			U
4.3.6.2.2	GEU Thermal Interface		A				U
4.3.7	Control and Data Requirements			T			SS
4.3.8	Environments			T			U
4.3.9	Reliability Requirements		A				U
4.4	**Telescope Subsystem**					N	
4.4.1	Subsystem Description					N	
4.4.2	Modes of Operation				D		S/S
4.4.3	Imaging Requirements					N	
4.4.3.1	System Aperture					N	
4.4.3.1.1	Positions of Stops and Pupils				D		S/S
4.4.3.1.2	System Aperture Size		A				S/S
4.4.3.2	Focal Length		A				S/S
4.4.3.3	Field of View		A				S/S
4.4.3.4	Focusing Range						
4.4.3.5	Spectral Bands		A				S/S
4.4.3.6	Optical Surface Durability		A				S/S
4.4.3.7	Obscurations		A				S/S
4.4.3.9	Optical Interfaces					N	
4.4.3.9.1	TSS to DSS Optical Interface				D		S/S

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
4.4.3.9.2	TSS to IFC Optical Interface				D		S/S
4.4.4	Radiometric Requirements					N	
4.4.4.1	Chopper	I					S/S
4.4.4.1.1	Chopper Performance			T			S/S
4.4.4.1.2	Chopper Temperature Stability			T			S/S
4.4.4.1.3	Chopper Reference Signal			T			S/S
4.4.4.2	Transmission		A				S/S
4.4.4.3	Transmissive Optical Elements	I					S/S
4.4.5	Mechanical Requirements					N	
4.4.5.1	Scanner Axis Requirements					N	
4.4.5.1.1	Azimuth Axis	I					S/S
4.4.5.1.2	Elevation Axis	I					S/S
4.4.5.2	Dynamics Requirements					N	
4.4.5.2.1	TSS Stiffness		A				S/S
4.4.5.2.2	Isolation from Baseplate				D		S/S
4.4.5.3	Mass	I					Unit
4.4.5.4	Envelope	I					S/S
4.4.5.5	Accessibility	I					S/S
4.4.5.6	TSS Mechanical Interfaces	I					S/S
4.4.6	Electrical Requirements					N	
4.4.6.1	Power Allocation			T			S/S
4.4.6.2	TSS Electrical Interfaces	I					S/S
4.4.7	Thermal Requirements			T			S/S
4.4.7.1	Thermal Interface	I					S/S
4.4.7.2	Operational Heaters						
4.4.7.3	Mirror Temperature Knowledge		A	T			S/S
4.4.7.4	Mirror Temperature Stability		A				S/S
4.4.7.5	Scan Mirror Temperature Gradients		A				S/S
4.4.8	Environments	I	A	T			S/S
4.4.9	Reliability Requirements	I					S/S
4.4.10	TSS Pointing and Scanning Requirements					N	
4.4.10.1	Boresight Angle and Axis Motion Requirements			T			S/S
4.4.10.2	Elevation Requirements					N	
4.4.10.2.1	Scan Rate			T			S/S
4.4.10.2.2	Elevation Angle Knowledge Requirements			T			S/S
4.4.10.2.3	Elevation Angle Jitter Requirements			T			S/S
4.4.10.2.4	Fixed Angle Mode			T			S/S
4.4.10.3	Azimuth Requirements					N	
4.4.10.3.1	Azimuth Scan Increment and Settling Time			T			S/S
4.4.10.3.2	Azimuth Slew Rate			T			S/S
4.4.10.3.3	Azimuth Pointing Accuracy			T			S/S
4.4.10.3.4	Azimuth Angle Jitter Requirements					N	S/S

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
4.4.10.3.5	Azimuth Angle Knowledge Resolution and Sampling			T			S/S
4.4.10.4	Calibration Aids						
4.5	**Detector Subsystem**					N	
4.5.1	Subsystem Description					N	
4.5.2	Modes of Operation						
4.5.3	Imaging Requirements					N	
4.5.3.1	Cold Shield	I	A				S/S
4.5.3.2	Optical Filters	I	A	T			S/S
4.5.3.3	Window	I	A	T			S/S
4.5.4	Radiometric Requirements					N	
4.5.4.1	Noise Equivalent Power Density (NEP’)		A	T			S/S
4.5.4.2	Responsivity						
4.5.4.2.1	Responsivity Uniformity		A	T			S/S
4.5.4.2.2	Responsivity Stability						
4.5.4.3	Frequency Response						
4.5.5	Mechanical Requirements					N	
4.5.5.1	Envelope	I					S/S
4.5.5.2	Mass	I					S/S
4.5.5.3	Mechanical Interface	I	A				S/S
4.5.5.4	Stability Requirements						
4.5.5.5	Mechanical Design		A				S/S
4.5.6	Electrical Requirements					N	
4.5.6.1	Output	I					S/S
4.5.6.2	Element Bias Power						
4.5.6.3	Temperature Sensors Bias Power						
4.5.6.4	Electrical Interface	I	A				S/S
4.5.6.5	Power Allocation						
4.5.7	Thermal Requirements					N	
4.5.7.1	Thermal Interface		A		D		S/S
4.5.7.2	DSS Cryogenic Heat Load		A		D		S/S
4.5.7.3	Thermal Cycling		A		D		S/S
4.5.8	Environments		A		D		S/S
4.5.9	Reliability Requirements		A				S/S
4.6	**In-flight Calibrator Subsystem**					N	-
4.6.1	Subsystem Description	I					SS
4.6.2	Modes of Operation			T			SS
4.6.3	Imaging Requirements		A				U
4.6.4	Radiometric Requirements		A				U
4.6.5	Mechanical Requirements					N	-
4.6.5.1	Envelope	I					U
4.6.5.2	Mass	I					U
4.6.5.3	Mechanical Interface	I					U

ITS Para #	Verification Cross Reference Matrix Paragraph Title	I	A	T	D	N	Level
4.6.5.4	Stability Requirements		A				U
4.6.6	Electrical Requirements					N	-
4.6.6.1	IFC Subsystem Secondary Power Requirements					N	-
4.6.6.2	Power Allocation			T			SS
4.6.7	Thermal Requirements					N	-
4.6.7.1	Temperature Range			T			U
4.6.7.2	Temperature Sensing			T			SS
4.6.7.3	Temperature Control			T			A
4.6.7.4	Thermal Interfaces		A				U
4.6.8	Environments			T			U
4.6.9	Reliability Requirements		A				U
4.7	**Instrument Processor Subsystem**					N	
4.7.1	Subsystem Description	I					S/S
4.7.1.1	Architectural Philosophy	I					S/S
4.7.1.2	Functional Interfaces Description	I					S/S
4.7.1.2.1	User Interface						
4.7.1.3	Operations Description	I					S/S
4.7.2	Modes of Operation	I					S/S
4.7.3	Functional Requirements					N	
4.7.3.1	Logical Interfaces					N	
4.7.3.1.1	Spacecraft Command and Telemetry (C&T) Interface	I					S/S
4.7.3.1.2	Gyro Subsystem Interface	I					S/S
4.7.3.1.3	Telescope Subsystem Interface	I					S/S
4.7.3.1.4	Detector Subsystem Interface						
4.7.3.1.5	IFC Subsystem Interface						
4.7.3.1.6	Sunshield Subsystem Interface	I					S/S
4.7.3.1.7	Cooler Subsystem Interface	I					S/S
4.7.3.1.8	Operational Heaters Interface		A				S/S
4.7.3.1.9	Power Subsystem Interface						
4.7.3.2	IPS Functions					N	
4.7.3.2.1	Spacecraft Communication					N	
4.7.3.2.1.1	Command Data						
4.7.3.2.1.2	Engineering Telemetry Data	I			D		S/S
4.7.3.2.1.3	Science Telemetry Data						
4.7.3.2.1.3.1	Science Telemetry Data Item List						
4.7.3.2.1.3.2	Memory Dump and Diagnostic Data						
4.7.3.2.2	Timing Signal Generation	I					S/S
4.7.3.2.2.1	Functional Description	I					S/S
4.7.3.2.2.2	Performance Requirements					N	
4.7.3.2.2.2.1	Output Frequencies, Waveforms and Timing			T			S/S
4.7.3.2.2.2.2	Phase Adjustment & Stability				D		S/S

ITS Para #	Paragraph Title	I	A	T	D	N	Level
	Verification Cross Reference Matrix	**Method of Verification**					
4.7.3.2.2.2.3	Operation Without the Chopper	I					S/S
4.7.3.2.3	Science Data Acquisition and Processing						
4.7.3.2.3.1	Detector Data						
4.7.3.2.3.1.1	Channel Gain Range and Stability						
4.7.3.2.3.1.2	Channel Offset Range and Stability						
4.7.3.2.3.1.3	Channel Linearity						
4.7.3.2.3.2	Scanner Angle Data	I					S/S
4.7.3.2.3.2.1	Scanner Angle Data Sampling Rate	I					S/S
4.7.3.2.3.3	Gyro Data	I					S/S
4.7.3.2.3.3.1	Gyro Data Sampling Rate	I					S/S
4.7.3.2.3.4	Time Stamp Data	I	A				S/S
4.7.3.2.4	Engineering Data Acquisition	I					S/S
4.7.3.2.4.1	Data Availability	I					S/S
4.7.3.2.4.2	Data Types					N	
4.7.3.2.4.2.1	Thermal Engineering Data	I					S/S
4.7.3.2.4.2.2	Power Engineering Data						
4.7.3.2.4.2.3	Instrument Operational Status	I					S/S
4.7.3.2.4.2.4	IPS Functional Status	I					S/S
4.7.3.2.4.2.5	TSS Performance Data						
4.7.3.2.4.3	Sample Rates	I					S/S
4.7.3.2.4.4	Data Range and Resolution	I		T			S/S
4.7.3.2.4.5	Data Processing					N	
4.7.3.2.5	Chopper Control						
4.7.3.2.6	Scanner Control					N	
4.7.3.2.6.1	Scanner Command Protocol	I					S/S
4.7.3.2.6.2	Scan Mode Select	I					S/S
4.7.3.2.6.3	Scan Profile Commands	I					S/S
4.7.3.2.6.4	Scan Synchronization Command	I		T			S/S
4.7.3.2.6.5	Reset Commands	I					S/S
4.7.3.2.6.6	Scanner Code and Parameter Load Commands						
4.7.3.2.6.7	Table Download	I					S/S
4.7.3.2.6.8	Scanner Operational Heaters						
4.7.3.2.7	IFC Temperature Control						
4.7.3.2.8	Sunshield Control					N	
4.7.3.2.8.1	Sunshield Drive Mechanism Control						
4.7.3.2.8.2	Sunshield Hold-down and Release Mechanism Control	I					S/S
4.7.3.2.9	Cooler Control	I					S/S
4.7.3.2.10	Operational Heater Control						
4.7.3.2.11	Power Control/Monitor	I					S/S
4.7.3.2.12	Instrument Control and Coordination Functions	I					S/S
4.7.3.2.12.1	Commanding Capabilities	I					S/S

ITS Para #	Verification Cross Reference Matrix Paragraph Title	I	A	T	D	N	Method of Verification Level
4.7.3.2.12.2	Instrument Monitoring and Safety Requirements	I					S/S
4.7.3.2.12.3	User Processes	I					S/S
4.7.3.2.12.4	Real-Time Executive Functions						
4.7.3.2.12.5	Reception of Spacecraft-Furnished Parameters	I					S/S
4.7.3.2.13	Code Maintenance Support	I					S/S
4.7.3.2.14	Memory Management						
4.7.3.2.15	Background Testing						
4.7.4	IPS Software Requirements					N	
4.7.4.1	Boot State Requirements			T			S/S
4.7.4.2	Operate State Requirements			T			S/S
4.7.5	Hardware Requirements					N	
4.7.5.1	Functional and Performance Requirements					N	
4.7.5.1.1	Processor					N	
4.7.5.1.1.1	Data Types Supported						
4.7.5.1.1.2	Operations Supported						
4.7.5.1.1.3	Processing Margin		A				S/S
4.7.5.1.2	Memory					N	
4.7.5.1.2.1	Non-Volatile Memory	I					S/S
4.7.5.1.2.1.1	Secure Memory	I					S/S
4.7.5.1.2.1.2	Reprogrammable Memory						
4.7.5.1.2.2	Volatile Memory	I					S/S
4.7.5.2	Mechanical Requirements					N	
4.7.5.2.1	Mass	I					Unit
4.7.5.2.2	Envelope	I					Unit
4.7.5.3	Electrical Requirements					N	
4.7.5.3.1	Input Power Requirements					N	
4.7.5.3.1.1	Power Allocation			T			S/S
4.7.5.3.1.2	Primary Power						
4.7.5.3.1.3	Secondary Power	I					S/S
4.7.5.3.2	Grounding Requirements						
4.7.5.3.2.1	Primary Power Grounding						
4.7.5.3.2.2	Secondary Power Grounding			T			S/S
4.7.5.3.3	Signal Electrical Interfaces					N	
4.7.5.3.3.1	Spacecraft						
4.7.5.3.3.2	Gyro Subsystem						
4.7.5.3.3.3	Telescope Subsystem						
4.7.5.3.3.4	Detector Subsystem						
4.7.5.3.3.5	IFC Subsystem						
4.7.5.3.3.6	Sunshield Subsystem						
4.7.5.3.3.7	Cooler Subsystem						
4.7.5.3.3.8	Operational Heaters						
4.7.5.3.3.9	Power Subsystem						

ITS Para #	Verification Cross Reference Matrix Paragraph Title	I	A	T	D	N	Level
4.7.6	Design Requirements					N	
4.7.6.1	Backplane Bus						
4.7.7	Thermal Requirements					N	
4.7.7.1	Subsystem Temperatures	I		T			S/S
4.7.7.2	Thermal Interfaces	I					S/S
4.7.8	Reliability Requirements		A				S/S
4.7.8.1	Functional Loss		A				S/S
4.7.8.2	Data Loss		A				S/S
4.7.8.3	Undetected Bit Errors		A				S/S
4.7.8.4	Uncommanded Resets		A				S/S
4.7.8.5	Subsystem Command Errors		A				S/S
4.7.9	Environments			T			S/S
4.8	**Cooler Subsystem**					N	
4.8.1	Subsystem Description					N	
4.8.2	Modes of Operation			T			S/S
4.8.3	Mechanical Requirements					N	
4.8.3.1	Envelope	I					Unit
4.8.3.2	Mass	I					Unit
4.8.3.3	Mechanical Configuration					N	
4.8.3.3.1	General Configuration	I					S/S
4.8.3.3.3	Cryovac Housing	I					S/S
4.8.3.3.3.1	Flexible Vacuum Enclosure Interface Port	I					S/S
4.8.3.3.3.2	Pumping Port	I					S/S
4.8.3.3.4	Cold Link and Flexible Vacuum Enclosure	I		T			S/S
4.8.3.3.5	Cooler Control Units (CCU's)	I					S/S
4.8.3.4	Mechanical Performance					N	
4.8.3.4.1	Peak Imbalance Force		A	T			S/S
4.8.3.4.2	Minimum Operating Frequency			T			S/S
4.8.3.4.3	Orientation in 1-g field		A	T			S/S
4.8.3.4.4	Caging of Cooler Mechanisms			T			S/S
4.8.3.4.5	Cryovac Housing					N	
4.8.3.4.5.1	Maximum Rate of Pressure Rise			T			S/S
4.8.4	Electrical Requirements					N	
4.8.4.1	Input Power Requirements					N	
4.8.4.1.1	Power Allocation			T			S/S
4.8.4.1.2	Primary Power		A	T			S/S
4.8.4.1.3	Secondary Power	I					S/S
4.8.4.2	Grounding Requirements					N	
4.8.4.2.1	Primary Power Grounding			T			S/S
4.8.4.2.2	Secondary Power Grounding			T			S/S
4.8.4.3	Command and Telemetry Requirements					N	
4.8.4.3.1	Autonomous Operation			T			S/S

Method of Verification: I, A, T, D, N, Level

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
4.8.4.3.2	Control Commands			T			S/S
4.8.4.3.2.1	IPS Control of Cold Node Temperature			T			S/S
4.8.4.3.2.2	Frequency Control			T			S/S
4.8.4.3.2.3	Active Vibration Cancellation			T			S/S
4.8.4.4	Engineering Data			T			S/S
4.8.4.5	Electrical Interfaces		A	T			S/S
4.8.5	Software Requirements	I					S/S
4.8.6	Thermal Requirements					N	
4.8.6.1	Temperature Set-point Range			T			S/S
4.8.6.2	Temperature Control Stability			T			S/S
4.8.6.3	Usable Cooling Power vs. Operating Frequency			T			S/S
4.8.6.4	Thermal Interfaces		A	T			S/S
4.8.6.4.1	Cooler Radiator Panel Interfaces		A				S/S
4.8.7	Environments					N	
4.8.7.1	Ground and Launch Environments		A	T			S/S
4.8.7.2	CSS On-orbit Environment			T			S/S
4.8.8	Reliability Requirements					N	
4.8.8.1	Lifetime		A				S/S
4.8.8.2	Cycles of Operation		A				S/S
4.8.8.3	Maintainability		A				S/S
4.8.8.4	Pressurized System Design						
4.9	**Power Subsystem**					N	
4.9.1	Subsystem Description					N	
4.9.2	Modes of Operation			T			S/S
4.9.3	Mechanical Requirements					N	
4.9.3.1	Envelope	I					S/S
4.9.3.2	Mass			T			S/S
4.9.3.3	Mechanical Interfaces	I					S/S
4.9.4	Electrical Interfaces					N	
4.9.4.1	Input Power Requirements					N	
4.9.4.1.1	Power Allocation Requirements	I		T			S/S
4.9.4.1.2	Primary Power	I		T			S/S
4.9.4.2	Output Voltage Requirements					N	
4.9.4.2.1	Instrument Processor Subsystem Secondary Power Interface			T			S/S
4.9.4.2.2	Gyro Subsystem Secondary Power Interface			T			S/S
4.9.4.2.3	Telescope System Secondary Power Interface			T			S/S
4.9.4.2.4	Detector Subsystem Secondary Power Interface					N	
4.9.4.3	Grounding Requirements					N	
4.9.4.3.1	Primary Power Grounding			T			S/S
4.9.4.3.2	Secondary Power Grounding			T			S/S
4.9.4.4	Command and Telemetry Requirements			T			S/S

	Verification Cross Reference Matrix	Method of Verification					
ITS Para #	**Paragraph Title**	**I**	**A**	**T**	**D**	**N**	Level
4.9.5	Thermal Requirements					N	
4.9.5.1	Thermal Interfaces		A				S/S
4.9.6	Environments			T			S/S
4.9.7	Reliability		A				S/S
5	Requirements Summary					N	
5.1	Subsystem Allocations					N	
6	Preparation for Delivery					N	
6.1	General						
6.2	Packing, Shipping Containers						
7	Appendices					N	
7.1	Acronym List					N	

Table 4.2
HIRDLS Instrument
Verification Cross Reference Matrix

4.2.2 Reporting of Verification-by-Analysis

The requirements listed in Table 4.2 that are verified by analysis shall be documented by Analysis Reports; the reports shall be available prior to the start of the environmental tests.

4.2.3 Test Conditions

Verification of individual subsystems and the integrated instrument shall occur under the conditions defined in the following subparagraphs:

4.2.3.1 Standard Ambient Conditions

Unless otherwise specified, tests shall be conducted under the standard ambient conditions described below.

Temperature:	+21° ±6°C (70°F +/- 11°F)
Atmospheric Pressure:	610 to 810 Torr (0.81 Bar to 1.08 Bar)
Relative humidity:	25 to 60 percent (no condensation)

4.2.3.2 Vacuum Test and Repressurization Conditions

Unless otherwise specified, vacuum testing shall be performed within a pressure range of 1.0×10^{-7} Torr < P < of 1.0×10^{-3} Torr (1.33×10^{-5} Pascal's < P < 0.133 Pascal's). When Vacuum Performance testing or Thermal Vacuum environmental testing occur which result in the subsystem or instrument temperature dropping below room temperature the chamber shall not be opened and the unit shall not be removed from the chamber until it has recovered to actual room temperature or warmer and has been held at that temperature in the chamber for not less than 1 hour.

Vacuum chamber repressurization shall be accomplished utilizing dry gaseous nitrogen GN_2 at or below the repressurization rate defined in the HIRDLS Contamination Control Plan

(CCP) PA-LOC-103. Further, the GN_2 used for repressurization shall be filtered to the level defined in the CCP.

4.2.3.3 Environmental Test Equipment Tolerance.

Unless otherwise specified, test apparatus shall be capable of controlling test conditions within the following tolerances of specified or equivalent units:

Test Condition		Tolerance
• a. Temperature:		± 2 °C or ± 5 % of difference from 21 °C, whichever is greater.
• b. Pressure:	equal to or greater than 0.1 Torr	±10%
	<0.1 Torr but > 4 x 10^{-4} Torr	±50%
	less than 4 x 10^{-4} Torr	±80%
• c. Relative humidity:		±5%
d. Steady (centrifuge) acceleration (g)		±5%
• e. Random Vibration (PSD 50Hz or narrower)		
	20 to 500 Hz	±1.5 dB
	500 to 2000 Hz	±3.0 dB
	Random overall g rms	±10%
• f. Sinusoidal Amplitude		±10%
g. Acceleration Spectral Density (g^2/Hz)		±3 dB, except -6dB for accumulated bandwidths of less then **(TBD)** Hz
• h. Random vibration acceleration (g, RMS):		±10%
• i. Time period:		±5% or ±**(TBD)** seconds, whichever is greater.
• j. Heat flux (W/m^2-s):		±10% or ±0.5 W/m^2-s, whichever is greater.

4.2.3.4 Test Equipment Accuracy's

The test equipment shall be calibrated in accordance with MIL-STD-45662 (TBV). Unless otherwise noted, the test equipment inaccuracies shall contribute no greater than 10 percent of the tolerance of the parameter being measured.

4.2.3.5 Retest

Retest requirements after modifications or changes to hardware, software, or test configuration have been incorporated shall be the same as though a failure had occurred in the area modified at the time the modifications are made. Retest requirements after failures that occur during testing depend on the nature of the failure, point of occurrence in the test program, degree of rework required for repair, criticality of equipment, and other factors. Retest after failures shall be under MRB action.

4.2.3.6 Test Discrepancies

If a test discrepancy occurs during environmental testing, the test shall be interrupted and the discrepancy verified. The disposition of the discrepancy shall be completed before the testing resumes. If the discrepancy is dispositioned as caused only by the test setup, operator error, or failure in the test equipment, the test being conducted at the time of the failure may be continued after correction of the test error, or if required repairs are completed, as long as the discrepancy did not result in an overstress test condition.

4.2.3.7 Failures During Test

If the discrepancy is dispositioned as a failure in the unit under test, the preliminary failure analysis and appropriate corrective action shall be completed in accordance with established procedures for handling a nonconforming unit. The test in which the failure occurred, and any previous tests whose results could possibly have induced the failure, or whose validity was compromised by the corrective action, shall then be entirely repeated unless MRB action specifies otherwise. Prior to environmental retest, consideration shall be given to possible damage caused by excessive repetition of tests.

4.2.3.8 Variation of Data During Environmental Tests.

To establish whether subsystem or Instrument performance has degraded, data shall be taken in all states before and after exposure to the environmental tests. The initial data taken prior to the environmental tests are to be used as baseline values to which those data taken after each environment will be compared. The significant change of any performance perameter shall be considered a failure.

4.2.4 Verification Tests

This section describes which tests and verifications are required for the delivered subsystems and Instrument in the various phases of the program. Unless otherwise specified, the tests shall be conducted in the order given. Details of the verification methods are given in section 4.2.1.

4.2.4.1 Subsystem and Unit Verifications

Prior to assembly of the instrument, verifications shall be performed on all subsystems at the respective RO's facility against their respective SSD's. Included as part of the subsystem testing shall be the formal verification of all requirements defined under the verification level column in Table 4.2 as subsystem, unit, assembly, subassembly, or part. Further, subsystem verifications shall include the verifications defined in the following subparagraphs.

4.2.4.1.1 Subsystem Physical properties

<u>Mass Properties:</u> The mass of each distinct unit within a subsystem shall be measured. The allowable measurement error on the sum total masses for each subsystem specified in ITS Section 5.1 is +/- 0.02 Kg or +/-1.0%, whichever is greater.

<u>Center of Mass:</u> The center-of-mass locations of each distinct unit within a subsystem shall be determined either by test or analysis. The allowable tolerance shall be +/-0.30 cm in each of three orthogonal axes.

<u>Geometry:</u> The geometry of each distinct unit within a subsystem, including size, shape, and volume shall be verified by inspection to comply with its respective envelope drawing.

<u>Mechanical Interface:</u> The mechanical interface of each distinct unit within a subsystem shall be verified for compliance with its respective envelope and interface drawings.

Protective Covers: The presence of all required protective covers shall be verified.

4.2.4.1.2 Electrical Interface Tests

An electrical interface test for each subsystem interface shall be devised by each subsystem RO and conducted to verify that all interface signals meet the requirements defined in its related Interface Control Documents and are within acceptable limits of the applicable performance specifications. Electrical harnesses shall be tested to verify proper routing of electrical signals and High Potential (High-Pot) tested in accordance with TBD.

4.2.4.1.3 Subsystem Environmental Verifications

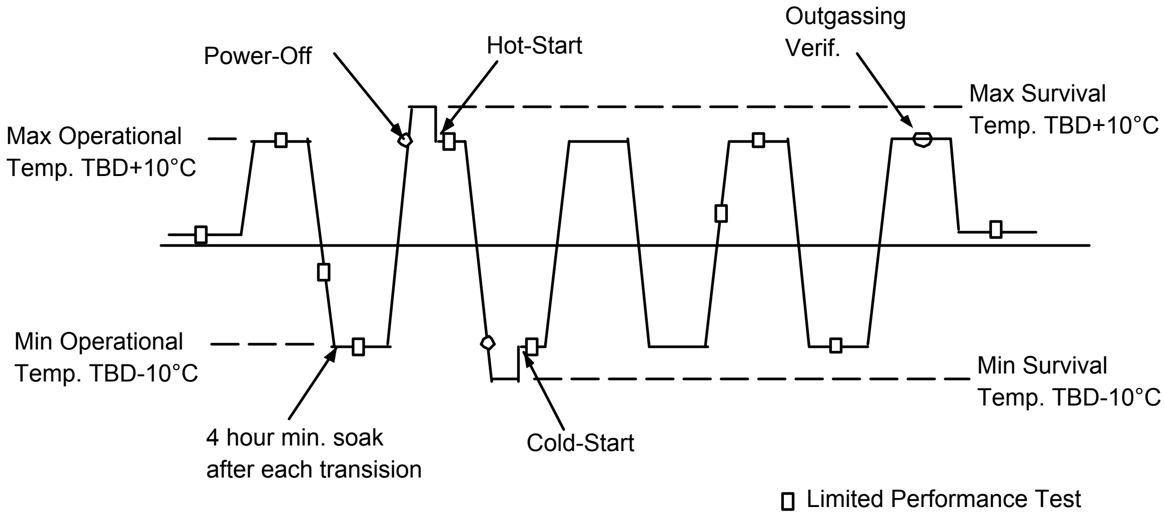
An environmental test program shall be devised by each subsystem RO and conducted to demonstrate each subsystems ability to meet the requirements defined in the ITS and its SSD after exposure to the mission environments. Each subsystem must conform to the verification requirements defined in section 3.0 of the MAR. As a minimum, each subsystem shall be subjected to the environmental tests defined in the following subparagraphs prior to integration into the instrument.

4.2.4.1.3.1 Subsystem Level Random Vibration Test

Each subsystem shall be subjected to Random Vibration testing. The random vibration input levels for each subsystem, or unit, shall be as specified in the HIRDLS Subsystem Environmental Requirements document (SP-HIR-188). This testing can be performed at the subsystem level or at the individual unit level. Testing shall be conducted with the subsystem, or unit, secured at its mounting locations to the shaker armature using a test fixture or fixture combination. Random vibration shall be applied to the subsystem, or unit, for a duration of 1 minute in each of three mutually orthogonal axes. Vibration shall be measured and controlled with an accelerometer mounted on the vibration test fixture near one of the instrument mounting points. At the completion of the test, the instrument shall be visually examined for evidence of damage or permanent deformation

4.2.4.1.3.2 Subsystem Level Thermal-Vacuum Test

Each subsystem, with the exception of the STH, shall be subjected to a 4 1/2 cycle thermal-vacuum test. The test shall commence with a "hot" cycle and shall conclude with a "hot" cycle. The temperature levels required for verification of each subsystem, or unit, shall be as specified in the HIRDLS Subsystem Environmental Requirements document (SP-HIR-188). The test profile is depicted in Figure 4.2.4.1.3.2. The pressure shall be $5x10^{-6}$ Torr ($6.64x10^{-4}$ Pascal's) or less. During subsystem thermal-vacuum testing, each subsystem shall be configured and operating in its "Operational Mode" except during periods of Limited Performance Testing and during Hot and Cold survival temperatures. The cycling test environment shall be initiated by a high temperature soak. Each cycle shall include a 4-hour soak at the high and low-temperature levels. Limited Performance tests shall be conducted for each subsystem at the extremes of the operating temperature range during the first and last thermal cycles, following the Hot and Cold starts, and during one Hot-to-Cold and one Cold-to-Hot transition. The transition between extreme temperature levels shall be made at a maximum rate of 20.0 deg. C per hour. The last three cycles shall be failure free.



Notes for profile:

A) Maintain plateaus for 4 hours minimum

B) Maximum rate of change between plateaus shall be nominally ±20°C/hour.

C) Limited performance testing shall be run during identified transitions

D) Instrument shall be configured into its operational State during T-Vac testing and outputs monitored except during periods of Limited Performance testing and during Hot and Cold survival temperatures

E) Pressure shall be Š 0.5×10^{-5} Torr (6.64×10^{-4} Pascals)

Figure 4.2.4.1.3.2
Subsystem Thermal-Vacuum Test Profile

4.2.4.1.3.3 Subsystem Level Outgassing Test

Outgassing verifications at the subsystem level shall occur by Test at vacuum with each subsystem at its highest operational temperature +10C. Outgassing levels for each subsystem shall be in accordance with the requirements defined in the HIRDLS Contamination Control Plan (PA-HIR-006). This verification can be included as part of the subsystem Thermal-vacuum testing as shown in Figure 4.2.4.1.3.2. Verifications shall be made to the levels defined in each SSD and may be performed either at the subsystem level or at individual unit levels. The subsystem Outgassing test shall incorporate a quartz crystal microbalance (QCM) and cold finger during outgassing testing as defined in paragraph 9.4 of the MAR (GSFC 424-11-13-01) or an equivalent method. During Outgassing testing the TQCM shall be held at 10°C below the minimum on-orbit operating temperature of the Unit under test.

4.2.4.1.3.4 Subsystem Level Failure-free Operation

At the conclusion of the performance verification program for each subsystem containing electrical components, each subsystem shall have demonstrated failure-free performance testing for at least the last 100 hours of operation. Failure-free operation during the subsystem thermal-vacuum test exposure is included as part of the demonstration. Major hardware changes during or after the verification program shall invalidate previous demonstration.

4.2.4.2 Instrument Level Pre-Environmental test Inspection

Before Instrument level Environmental testing, the instrument shall be inspected for compliance with the requirements listed in Table 4.2 under Method of Verification: Inspection, Verification level: Instrument. The following physical properties shall also be verified:

a. Mass Properties: The mass of the assembled Instrument shall be measured. The allowable tolerance shall be ±0.10Kg.

b. Center of Mass: The center-of-mass of the assembled instrument shall be determined either by test or analysis. The allowable tolerance shall be +/-0.50cm in each of three orthogonal axes.

c. Geometry: The geometry of the assembled Instrument, including size, shape, and volume shall be verified by inspection to comply with its respective envelope drawing.

d. Mechanical Interface: The mechanical interface of assembled Instrument shall be verified for compliance with its respective envelope drawing.

e. Transportability: The instrument shipping container/storage case shall be evaluated for satisfaction of the requirements specified in the HIRDLS Mechanical Ground Support Equipment Specification SP-HIR-058.

f. Protective Covers: The presence of all required protective covers shall be verified.

4.3 Proto-flight Tests

The instrument shall be subjected to the Proto-flight tests specified herein. The test sequences shall be as shown in Figure 4.3. Prior to the start of the environmental testing, the instrument shall have satisfied the inspection and analysis requirements defined in Table 4.2 and the Comprehensive Performance Test requirements defined in paragraph 4.3.1.1. Further, a pre-environmental Test Review shall be held in accordance with the Instrument Integrators Statement of Work.

4.3.1 Demonstrations, Functional and Performance Tests

The following demonstrations and functional tests shall be performed on the instrument to verify the functional and performance requirements of the instrument.

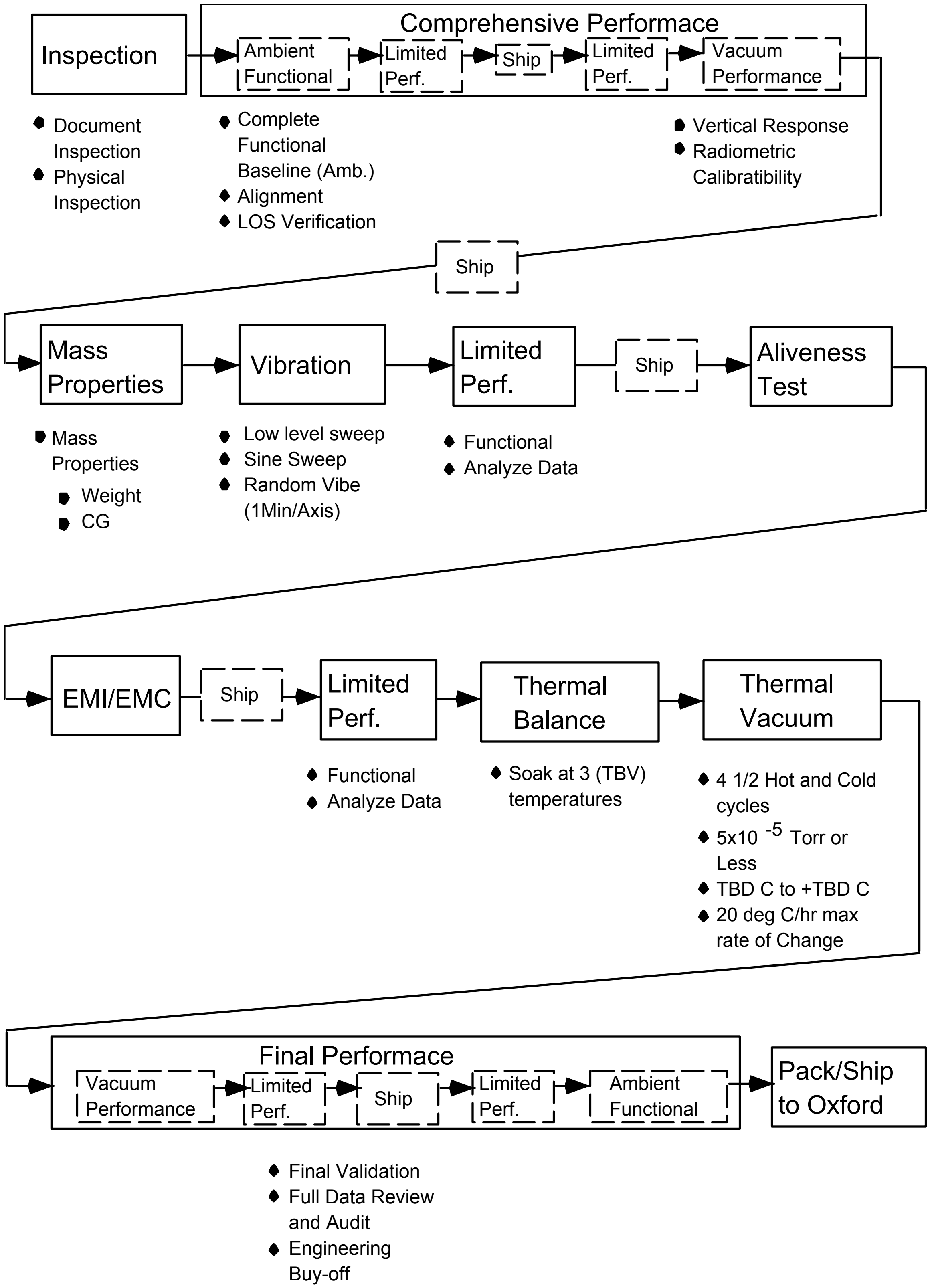


Figure 4.3
Instrument Test Flow (PFM)

4.3.1.1 Comprehensive Performance Test

A Comprehensive Performance Test shall be performed on the instrument to verify all Instrument level functional and performance requirements defined in the ITS. This test is intended to be the most comprehensive of all future tests. All interface, functional, performance, and software requirements are to be verified. Because of the complexity and special test equipment required to verify some of the HIRDLS Instrument level performance requirements (e.g. LOS requirements), the Comprehensive Performance Test may be divided into a series of test and associated test environments. The functional and LOS performance testing may be performed in air, Radiometric testing shall be performed in vacuum. The instrument requirements to be verified during the Comprehensive Performance Test are defined in Table 4.3.1.1.

ITS Para #	Title
3.2.1	Off Mode
3.2.2	Survival Mode
3.2.3	Idle Mode
3.2.4	Low Power Mode
3.2.5	Standby 1 Mode
3.2.6	Standby 2 Mode
3.2.7	Mission Mode
3.3.1	Vertical Field of View
3.3.2	Vertical Response
3.3.4	Horizontal Field of View
3.3.5	Out-of-Field Response
3.3.6.1	Object Distance
3.4.4.2	Radiometric Channel Gain
3.4.4.2.1	Radiometric Channel Gain Stability
3.4.4.3	Radiometric Channel Offset
3.4.4.3.1	Radiometric Channel Offset Stability
3.4.4.4	End-to-End Channel Transfer Funct.
3.4.4.5	Elect. Crosstalk bet. Radiometric Channels
3.4.4.5.1	Elect. Crosstalk under Test Overload
3.4.4.6	Radiometric Channel Overload Recovery
3.4.4.7	Radiometric Channel Slew Rate
3.4.5	Radiometric Noise
3.4.6	Dynamic Range
3.4.7.3.2	Radiometric Sampling Rate
3.5.1.1	Elevation Scan Range
3.5.1.2	Elevation Scan Rate
3.5.1.4	Fixed Angle Mode
3.5.1.5	Elevation Angle Jitter
3.5.2.1	Azimuth Scan Range
3.5.2.2	Azimuth Scan Step and Settle
3.5.2.3	Azimuth Pointing Accuracy
3.5.3.2	TRCF-to-IRCF Alignment

ITS Para #	Title
3.7.1	Electrical Interface with Spacecraft
3.7.1.1	Power Buses
3.7.1.1.1	Quiet Power Bus
3.7.1.1.2	Noisy Power Bus
3.7.1.1.3	Survival Heater Power Bus
3.7.2.3	Input Voltage
3.7.2.4	Input Voltage Ripple
3.7.2.5	Impedance
3.7.2.6.1	Unannounced Power Removal
3.7.2.6.2	Polarity Reversal
3.7.2.6.3	Loss of One Side of Power Supply
3.7.2.6.4	Overvoltage
3.7.2.7.1	Transients
3.7.2.7.2	Current Ripple
3.7.3.2	Primary Power Grounding
3.7.3.3	Secondary Power Grounding
3.7.3.5	Thermal Blanket Grounding
3.7.3.6	Bonding
3.7.3.6.2	Electrical Connector Bonding
3.7.4.1	Primary Power
3.7.4.2	Secondary Power
3.7.8	Survival Heaters
3.8.1	Thermal Interface with Spacecraft
3.8.1.1	Thermal Design
3.8.1.2	Heat Transfer
3.8.2	Instrument Temperatures
3.9	Command and Data Handling (C&DH) Specifications
3.9.3.5.4	Time Marks and Time Code Data
3.9.3.6.1	Engineering Telemetry
3.9.3.6.2	Science Telemetry
3.9.3.6.4	Instrument to Spacecraft Transmission Time-outs
3.10.2	Flight Software Requirements
3.10.2.5	Flight Software On-Orbit Installation and Verif.

Table 4.3.1.1
Comprehensive Performance Test Elements

4.3.1.2 Limited Performance Test

Limited Performance tests shall be performed on the instrument before, during, and after environmental tests as appropriate, in order to demonstrate that functional capability of the instrument has not been degraded by the tests. These tests, combined with the comprehensive performance test and the Final Performance Test shall form the basis of performance degradation trending. The instrument requirements to be verified during the Limited Performance Test are defined in Table 4.3.1.2.

ITS Para #	Title
3.2.1	Off Mode
3.2.2	Survival Mode
3.2.3	Idle Mode
3.2.4	Low Power Mode
3.2.5	Standby 1 Mode
3.2.6	Standby 2 Mode
3.2.7	Mission Mode
3.4.4.2b	Radiometric Channel Gain (Against IFC)
3.4.4.3.2	Radiometric Sampling Rate
3.5.1.1	Elevation Scan Range (Modified)
3.5.1.2	Elevation Scan Rate
3.5.1.4	Fixed Angle Mode
3.5.2.1	Azimuth Scan Range
3.5.2.2	Azimuth Scan Step and Settle
3.7.1	Electrical Interface with Spacecraft
3.7.1.1	Power Buses
3.7.1.1.1	Quiet Power Bus
3.7.1.1.2	Noisy Power Bus
3.7.1.1.3	Survival Heater Power Bus
3.7.2.3	Input Voltage
3.7.2.4	Input Voltage Ripple
3.7.2.5	Impedance
3.7.2.7.1	Transients
3.7.2.7.2	Current Ripple
3.9.3.5.4	Time Marks and Time Code Data
3.9.3.6.1	Engineering Telemetry
3.9.3.6.2	Science Telemetry
3.9.3.6.4	Instrument to Spacecraft Transmission Time-outs

Table 2.3.1.2
Limited Performance Test Elements

4.3.1.3 Aliveness Test

An Aliveness test shall be performed to verify that the subsystem and its major components are functioning, and that changes or degradation have not occurred as a result of environmental exposure, handling, transportation, or faulty installation. This test shall be performed after major environmental tests, handling and transportation of the instrument as shown in Figure 4.3. The instrument requirements to be verified during the Aliveness Test are defined in Table 4.3.1.3.

ITS Para #	Title

ITS Para #	Title
3.2.1	Off Mode
3.2.2	Survival Mode
3.2.3	Idle Mode
3.2.4	Low Power Mode
3.2.5	Standby 1 Mode
3.2.6	Standby 2 Mode
3.2.7	Mission Mode
3.4.4.2b	Radiometric Channel Gain (Against IFC)
3.9.3.6.1	Engineering Telemetry
3.9.3.6.2	Science Telemetry

Table 4.3.1.3
Aliveness Test Elements

4.3.1.4 Final Performance Test

Following the completion of all testing, the instrument shall be subjected to a final performance test. The Final Performance Test shall re-verify the elements defined in Table 4.3.1.4 which were verified during the Comprehensive Performance Test. For the performance parameters requiring extensive calibration, the Final Performance Testing may include reduced testing in those specific areas to confirm that the calibrations remain valid. The Final Performance testing may be divided into two separate tests environments: functional testing and LOS performance testing may be performed in air, Radiometric testing shall be performed in vacuum. Further, it is acceptable to reverse the order of vacuum and ambient testing.

ITS Para #	Title
3.2.1	Off Mode
3.2.2	Survival Mode
3.2.3	Idle Mode
3.2.4	Low Power Mode
3.2.5	Standby 1 Mode
3.2.6	Standby 2 Mode
3.2.7	Mission Mode
3.3.1	Vertical Field of View
3.3.2	Vertical Response
3.3.4	Horizontal Field of View
3.3.5	Out-of-Field Response
3.3.6.1	Object Distance
3.4.4.2	Radiometric Channel Gain
3.4.4.2.1	Radiometric Channel Gain Stability
3.4.4.3	Radiometric Channel Offset
3.4.4.3.1	Radiometric Channel Offset Stability
3.4.4.4	End-to-End Channel Transfer Funct.
3.4.5	Radiometric Noise
3.4.6	Dynamic Range
3.4.7.3.2	Radiometric Sampling Rate
3.5.1.1	Elevation Scan Range
3.5.1.2	Elevation Scan Rate
3.5.1.4	Fixed Angle Mode
3.5.1.5	Elevation Angle Jitter
3.5.2.1	Azimuth Scan Range
3.5.2.2	Azimuth Scan Step and Settle
3.5.2.3	Azimuth Pointing Accuracy
3.5.3.2	TRCF-to-IRCF Alignment
3.7.1	Electrical Interface with Spacecraft
3.7.1.1	Power Buses
3.7.1.1.1	Quiet Power Bus
3.7.1.1.2	Noisy Power Bus
3.7.1.1.3	Survival Heater Power Bus
3.7.2.3	Input Voltage
3.7.2.4	Input Voltage Ripple
3.7.2.5	Impedance
3.7.2.7.1	Transients
3.7.2.7.2	Current Ripple
3.7.3.2	Primary Power Grounding
3.7.3.3	Secondary Power Grounding
3.7.4.1	Primary Power
3.7.4.2	Secondary Power

ITS Para #	Title
3.7.8	Survival Heaters
3.8.1	Thermal Interface with Spacecraft
3.8.1.1	Thermal Design
3.8.2	Instrument Temperatures
3.9	Command and Data Handling (C&DH) Specifications
3.9.3.5.4	Time Marks and Time Code Data
3.9.3.6.1	Engineering Telemetry
3.9.3.6.2	Science Telemetry
3.9.3.6.4	Instrument to Spacecraft Transmission Time-outs

Table 4.3.1.4
Final Performance Test Elements

4.3.2 Environmental Testing.

The instrument shall be subjected to the sequence of environmental tests specified in the Instrument Test Flow Figure 4.3. The following subparagraphs describe the individual environmental tests and state the required verification levels defined in GIRD section 10 and MAR section 3.4.

4.3.2.1 Low Level Sine Sweep

The HIRDLS instrument shall be subjected to a low level sine sweep from 0 Hz to 2000 Hz to verify the Structural Mathematical Model adequately represents the hardware's dynamic characteristics. This testing shall be performed once prior to all other structural testing to ensure no unmodeled structural modes exist within the instrument which could cause structural failure in subsequent vibration tests and again following the random vibration testing to verify the structural signature did not change. The input level shall be sufficiently high to excite the first 10 structural modes but low enough to ensure no damage will occur

4.3.2.1.1 Low Level Sine Sweep Test Description

The Low Level Sine Sweep test shall be conducted with the instrument secured at its mounting locations to a shaker armature or interface test fixture. A sine sweep shall be applied to the instrument parallel to each of three mutually orthogonal axes. Vibration input shall be measured and controlled with an accelerometer mounted on the vibration fixture near one of the mounting points. Accelerometers shall be mounted on the instrument to measure structural responses.

The responses in g, shall be measured over the frequency domain. The responses divided by the input g-level provides the amplification factor versus frequency. At each natural frequency, the amplification factor curve will exhibit a peak, and the factor will be much greater than unity. The instrument response shall be measured from 0 Hz to 2000 Hz. The measured responses shall exhibit no instrument natural frequency less than 50 Hz.

4.3.2.2 Random Vibration Test.

The HIRDLS instrument shall be subjected to random vibration testing to demonstrate its ability to meet the requirements defined in the ITS after exposure to the spacecraft random vibration environment. The instrument shall be subjected to vibration testing for a duration of 1 minute in each of three mutually orthogonal axes. The shaped frequency spectrum of the input shall be as defined in GIRD Table 10-1 (repeated here as Figure 4.3.2.2).

4.3.2.2.1 Random Vibration Test Description

The Random Vibration testing shall be conducted with the instrument secured at its mounting locations to the shaker armature using a test fixture or fixture combination. Random vibration shall be applied to the instrument parallel to each of three mutually orthogonal axes. Vibration shall be measured and controlled with an accelerometer mounted on the vibration test fixture near one of the instrument mounting points. At the completion of the test, the instrument shall be visually examined for evidence of damage or permanent deformation.

Vibration Test Levels
Proto-flight Components

Frequency	Acceleration Spectral Density (G2/Hz)
20	0.026
20 to 50	+6 dB/oct
50 to 800	0.16
800 to 2000	-6 dB/oct
2000	0.026
Overall	14.1 Grms

The acceleration spectral density (ASD) level may be reduced for components weighing more than 25 Kg according to:

$$\text{dB reduction} = 10\ \text{LOG}(W/25)$$

$$ASD_{(25\ \text{to}\ 400)} = 0.16 \times (25/W)$$

where W = component weight in Kg

The slope shall be maintained at $\pm$ 6 dB/Oct for components weighing up to 65 kg. Above that weight, the slopes shall be adjusted to maintain an ASD level of 0.01 G^2/Hz at 20 and 200 Hz.

For components weighing over 200 Kg, the test specification shall be maintained at the level for 200 Kg

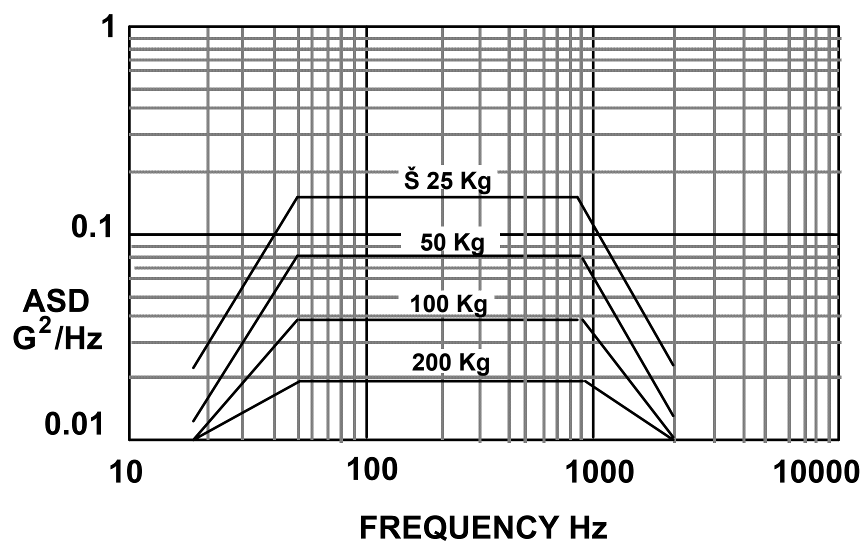


Figure 4.3.2.2
Random Vibration Test Spectrum

4.3.2.3 Sine Vibration

The HIRDLS Instrument shall be subjected to Proto-flight sine vibration test levels specified in GIRD Table 10-3 and Figure 10-1 (repeated here as Table 4.3.2.3 and Figure 4.3.2.3) in each of three orthogonal axes. During this test the instrument shall be in the launch configuration. There shall be one sweep from 5 Hz to 50 Hz for each axis. The Proto-flight sweep rate shall be 4 oct/min except in the frequency range of 25-35 Hz, where the sweep rate shall be 1.5 oct/min.

4.3.2.3.1 Sine Vibration Test Description

The Sine Vibration testing shall be conducted with the instrument secured at its mounting locations to the shaker armature using a test fixture or fixture combination. A sine sweep shall be applied to the instrument parallel to each of three mutually orthogonal axes. Vibration shall be measured and controlled with an accelerometer mounted on the vibration test fixture near one of the instrument mounting points. At the completion of the test, the instrument shall be visually examined for evidence of damage or permanent deformation.

Frequency	Amplitude/Acceleration
5 to 18 Hz	Displacement = 12 mm (double amplitude)
18 to 50 Hz	8 G peak

Table 4.3.2.3
Sinusoidal Proto-flight/Qualification Test Levels

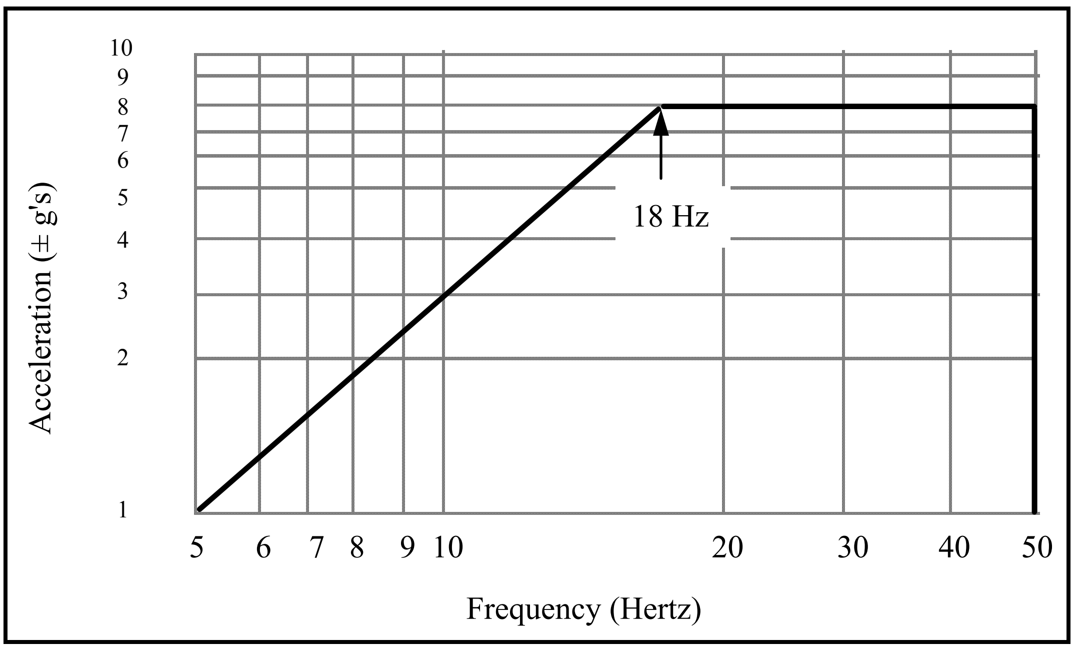


Figure 4.3.2.3
Sinusoidal Proto-flight Test Levels

4.3.2.4 Electromagnetic Compatibility Test

The instrument shall undergo electromagnetic compatibility testing defined in the following subparagraphs to demonstrate that the electromagnetic compatibility characteristics of the EOS environment under normal operating conditions will not result in malfunction of the HIRDLS instrument and the it will not emit, radiate, or conduct interference which will result in malfunction of other EOS components or instruments.

4.3.2.4.1 Conducted Emission, Power Leads (CE01/CE03)

Narrowband conducted emissions of a component/instrument on power and power return leads shall be limited to the levels specified in Figure 10-6 of the GIRD when measured in accordance with the CE01 (30 Hz to 20 KHz) and CE03 (20 KHz to 50MHz) test methods of MIL-STD-462. The measurement bandwidth shall be as specified in GIRD Figure 10-8 (repeated here as Figure 4.3.2.4.1-A).

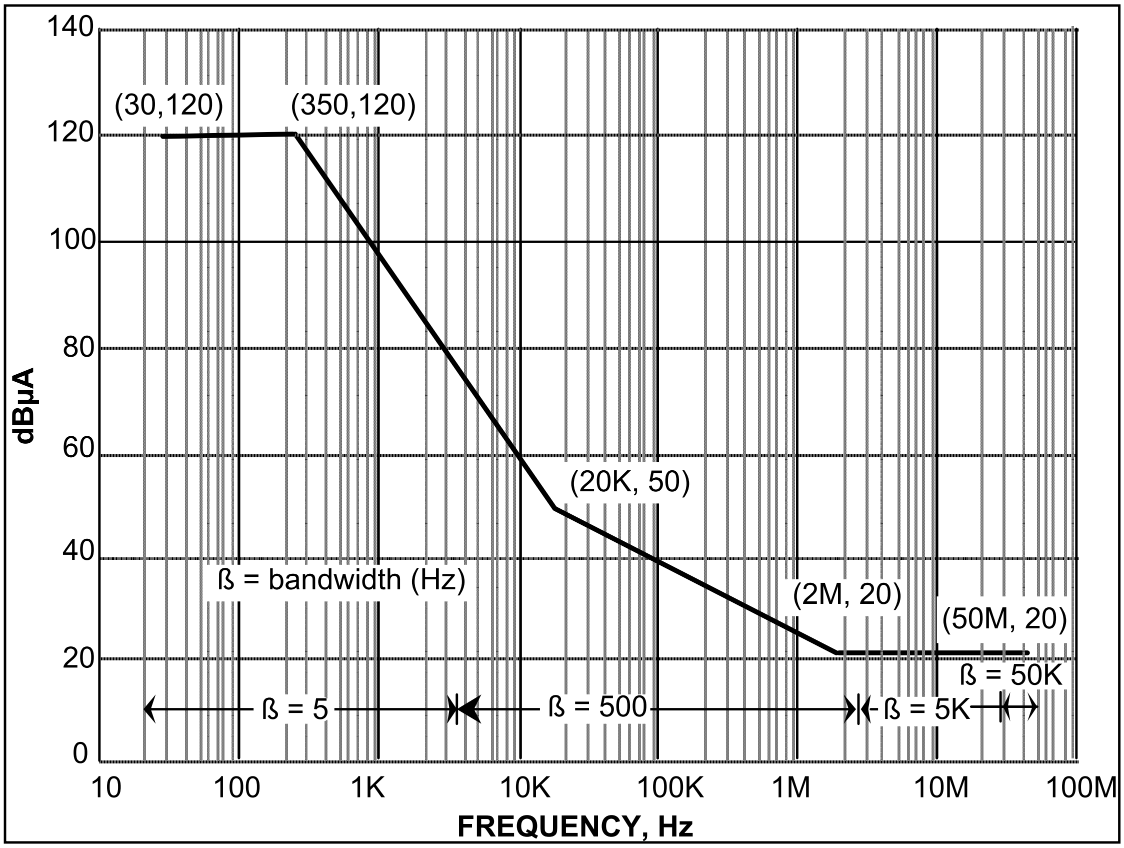


Figure 4.3.2.4.1-A
CE01/CE03 Narrowband Conducted Emission Limit

Broadband conducted emissions of a component/instrument on power and power return leads shall be limited to the levels specified in GIRD Figure 10-9 (repeated here as Figure 4.3.2.4.1-B) over the frequency range of 20 KHz to 50 MHz, when measured in accordance with the CE03 test method of MIL-STD-462.

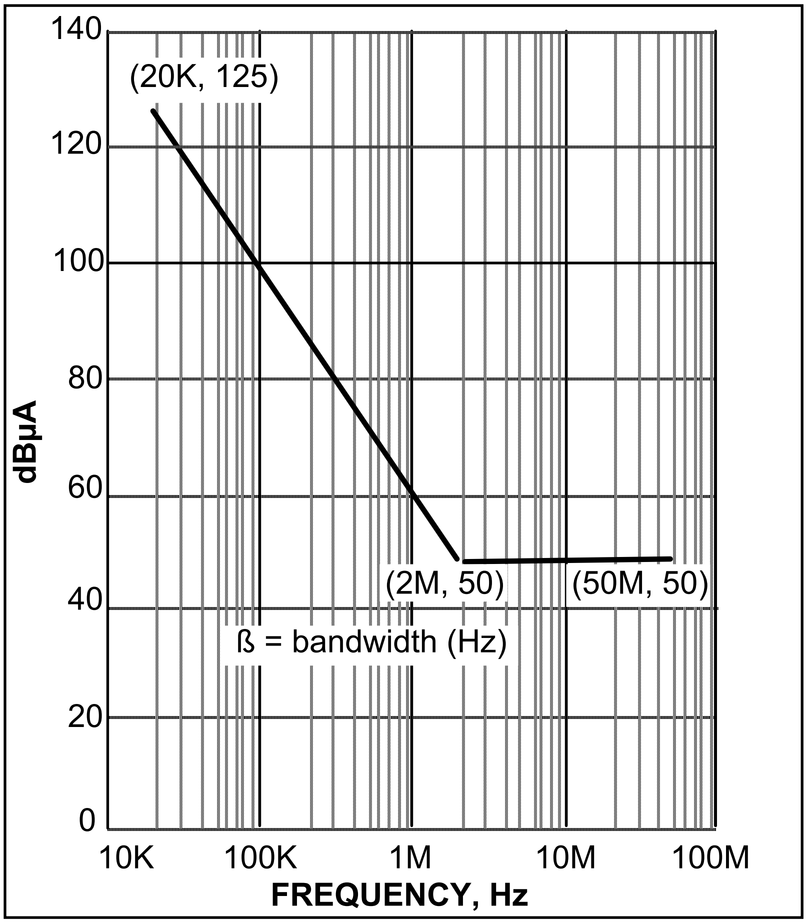


Figure 4.3.2.4.1-B
CE03 Broadband Conducted Emission Limit

4.3.2.4.2 Conducted Susceptibility, Power Leads (CS01/CS02)

A sine wave having the amplitude of 3 V peak-to-peak shall be superimposed on the minimum and maximum bus voltage of each input power lead for the quiet and survival heater power buses using the CS01 (30 Hz to 50 KHz) and CS02 (50 KHz to 400 MHz) test methods of MIL-STD-462. The test shall be conducted over the frequency range of 30 Hz to 400 MHz as defined in GIRD Figure 10-10 (repeated here as Figure 4.3.2.4.2). The component/instrument shall not exhibit any undesired response, malfunction or performance degradation beyond the tolerances allowed by its specification. If performance degradation beyond the tolerances is observed, the amplitude of the sine wave shall be decreased to determine the susceptibility threshold.

For the noisy bus, the maximum amplitude shall be 7 V peak-to-peak from 30 Hz to 2 KHz, then falls log-linearly to 3 V peak-to-peak at 50 KHz and remains at 3 V to 400 MHz (Figure 4.3.2.4.2).

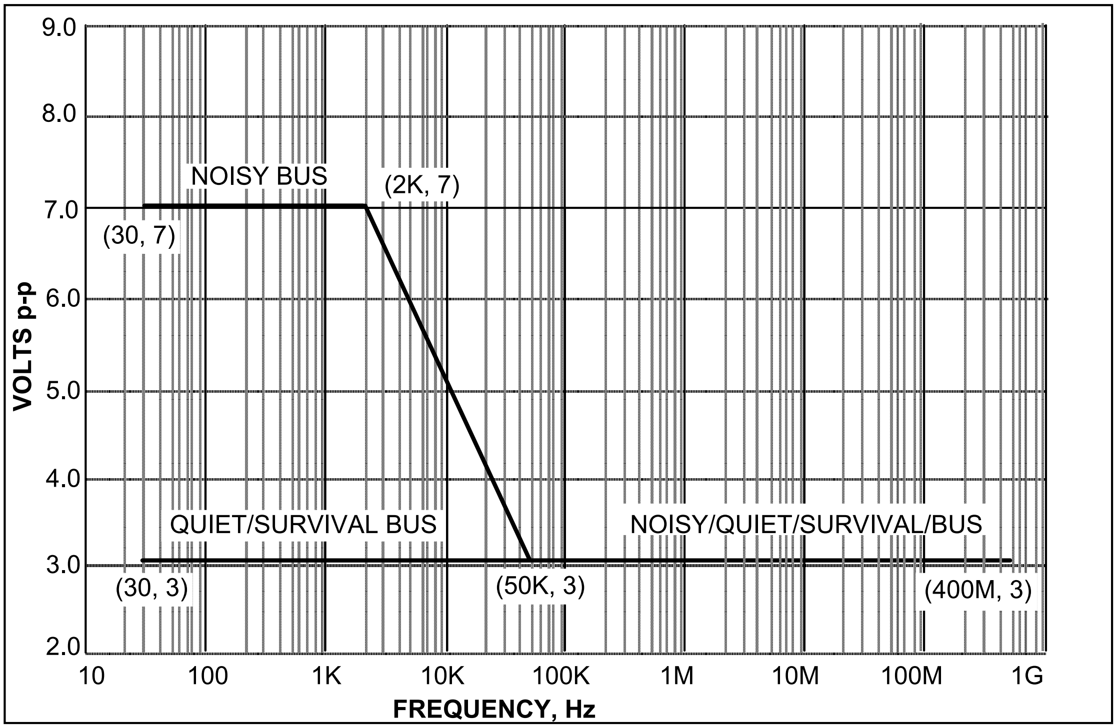


Figure 4.3.2.4.2
CS01/CS02 Conducted Susceptibility Limit

4.3.2.4.3 Conducted Susceptibility, Spike, Power Leads (CS06)

Positive and negative spikes having a peak voltage equal to the steady state input power bus voltage and a pulse width of 10 micro-seconds shall be applied to each input power lead using the CS06 test method of MIL-STD-462. The wave shape of the spike is defined in GIRD Figure 10-11 (repeated here as Figure 4.3.2.4.3). The spikes shall be applied for a duration of 5 minutes at a repetition rate of 60 pulses/sec. The component/instrument shall not exhibit any undesired response, malfunction or performance degradation beyond the tolerances allowed by its specification.

4.3.2.4.4 Radiated Emission, Magnetic Field

4.3.2.4.4.1 Radiated AC Magnetic Field Emissions (RE01/RE04)

The radiated ac magnetic field levels from a component/instrument shall be limited to 60 dB above 1 pico-Tesla between 20 Hz to 50 KHz using the RE04 test method of MIL-STD-462. The measurement bandwidth shall be 10 Hz between 20 Hz and 200 Hz, 100 Hz between 200 Hz and 20 KHz, and 1 KHz between 20 KHz and 50 KHz.

4.3.2.4.4.2 Radiated DC Magnetic Field Emissions

The residual magnetic dipole moment of a component/instrument shall be less than 0.5 A-m^2.

4.3.2.4.4.3 Magnetic Fields Documentation

The instrument provider shall measure the intensity and direction of the magnetic field produced by the instrument. These data shall be documented in the ICD. Analysis may be substituted for measurement with the approval of the respective GSFC EOS project.

4.3.2.4.5 Radiated Emission, Electric Field (RE02)

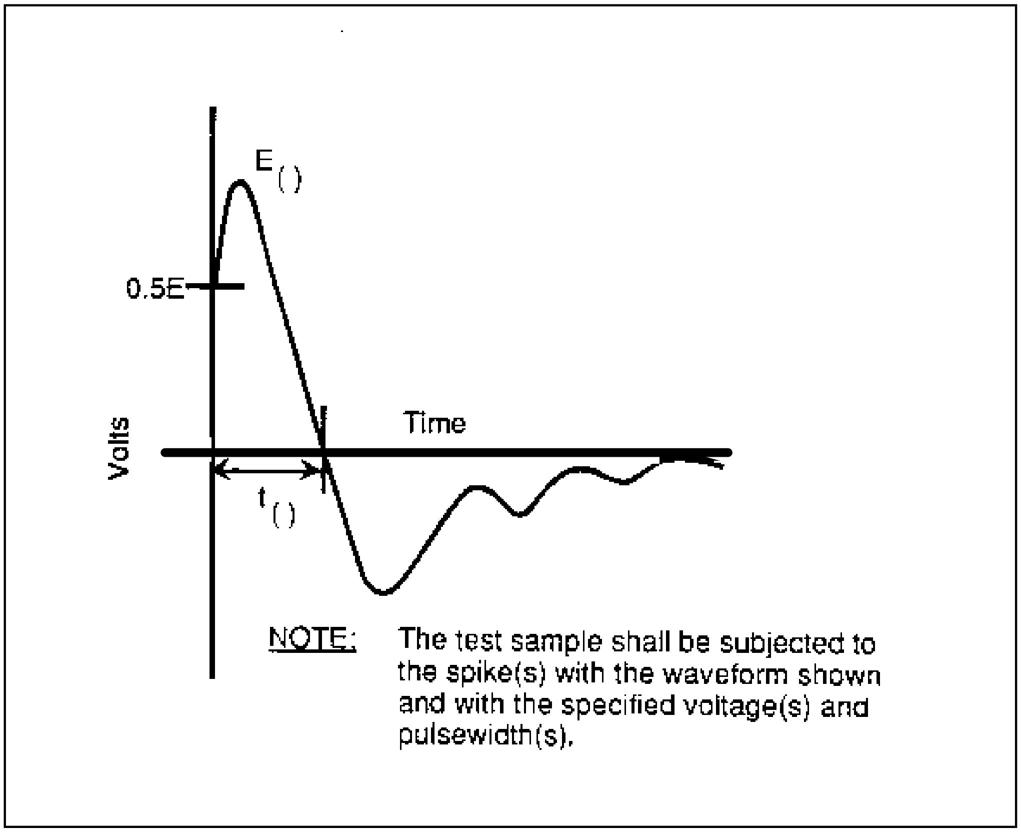


Figure 4.3.2.4.3
CS06 Spike Waveshape

4.3.2.4.5.1 Narrowband Emission

Narrowband radiated electric field emissions from a component/instrument, when measured according to the RE02 test method of MIL-STD-462 over the frequency range of 14 KHz to 18 GHz, shall be within the limit specified in GIRD Figure 10-12 (repeated here as Figure 4.3.2.4.5.1). The exception is for a spacecraft with passive microwave instruments onboard, where the limit shall be modified to include notches at the microwave instrument receiver frequencies (for the EOS-PM mission the frequencies and notches are specified in GIRD Table 10-9 (repeated here as Table 4.3.2.4.5.1) and the limit at 18 GHz shall be applicable from 18 GHz to the maximum microwave instrument receiver frequency on that spacecraft. The measurement bandwidth shall be 500 Hz between 14 KHz and 2.5 MHz, 5 KHz between 2.5 MHz and 30 MHz, 50 KHz between 30 MHz and 1 GHz, and 100 KHz between 1 GHz and 18 GHz.

4.3.2.4.5.2 Broadband Emission

Broadband radiated electric field emissions from a component/instrument, when measured according to the RE02 test method of MIL-STD-462 over the frequency range of 14 KHz to

18 GHz, shall be within the limit specified in Figure 4.3.2.4.5.2. The exception is for a spacecraft with passive microwave instrument(s) onboard, where the limit shall be modified to include notches at the microwave instrument receiver frequencies (for the EOS-PM mission the frequencies and notches are specified in Table 4.3.2.4.5.1) and the limit at 18 GHz shall be applicable from 18 GHz to the maximum microwave instrument receiver frequency on that spacecraft.

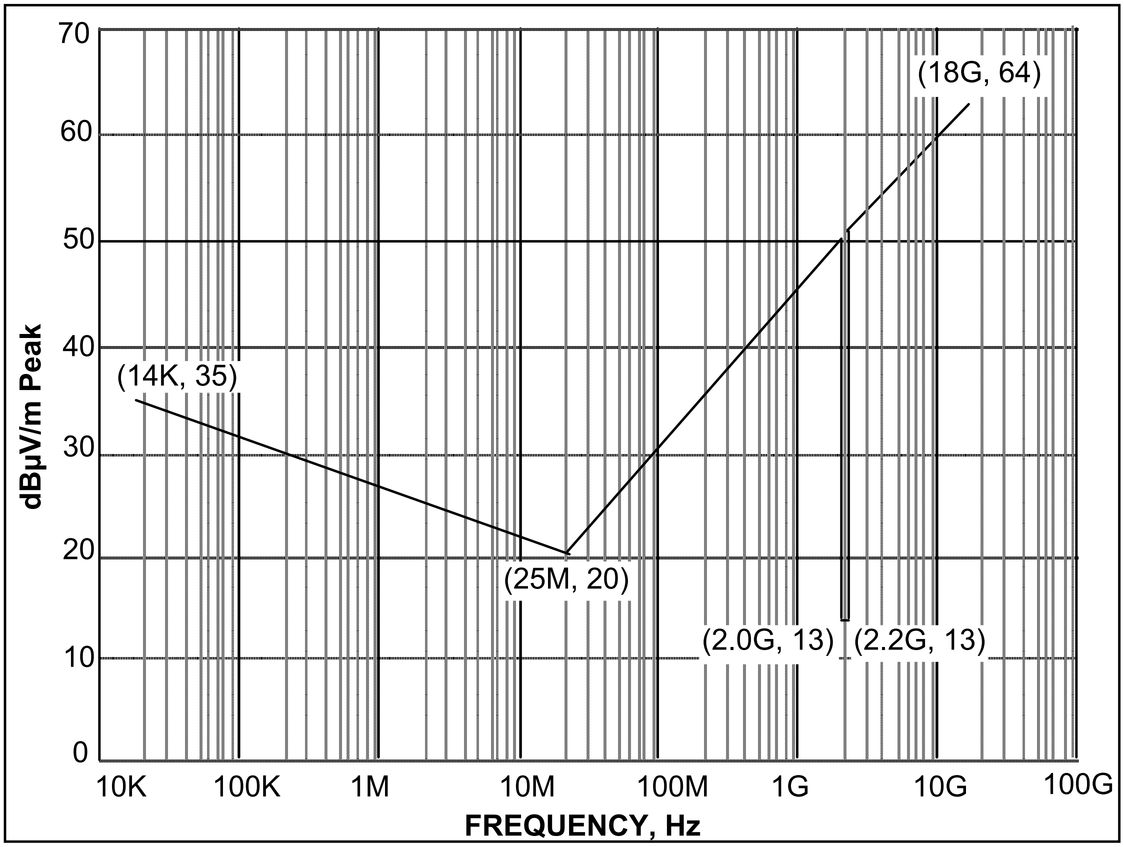


Figure 4.3.2.4.5.1
RE02 Narrowband Radiated Emission Limit

Frequency	Bandwidth	EMI Sensitivity	Instrument
6,800 MHz	200 MHz	-130 dBm	MIMR
10,650 MHz	100 MHz	-130 dBm	MIMR
18,700 MHz	200 MHz	-126 dBm	MIMR
23,800 MHz	400 MHz	-123 dBm	MIMR
23,800 MHz	270 MHz	-88 dBm	AMSU-A
31,400 MHz	180 MHz	-88 dBm	AMSU-A
36,500 MHz	1,000 MHz	-119 dBm	MIMR
50,300 MHz	180 MHz	-91 dBm	AMSU-A
52,800 MHz	400 MHz	-87 dBm	AMSU-A
53,481 MHz	170 MHz	-88 dBm	AMSU-A
53,711 MHz	170 MHz	-88 dBm	AMSU-A
54,400 MHz	400 MHz	-87 dBm	AMSU-A
54,940 MHz	400 MHz	-87 dBm	AMSU-A
55,500 MHz	330 MHz	-88 dBm	AMSU-A
57,290 MHz	776 MHz	-84 dBm	AMSU-A
89,000 MHz	3,000 MHz	-75 dBm	AMSU-A
89,000 MHz	6,000 MHz	-114 dBm	MIMR
89,000 MHz	3,000 MHz	-79 dBm	MHS
150,000 MHz	2,000 MHz	-113 dBm	MHS
183,311 MHz	2,014 MHz	-113 dBm	MHS

Table 4.3.2.4.5.1
EOS-PM Instrument Receiving Frequencies:

Note: No margin has been included for either the bandwidth or the sensitivity.

4.3.2.4.6 Radiated Susceptibility, Magnetic Field

4.3.2.4.6.1 Radiated AC Magnetic Field Susceptibility (RS01)

The component/instrument shall not exhibit any undesired response, malfunction or performance degradation beyond the tolerances allowed by its specification when it is subjected to the ac magnetic field defined in GIRD Figure 10-14 (repeated here as Figure 4.3.2.4.6.1). The RS01 test method of MIL-STD-462 shall be used for measurement.

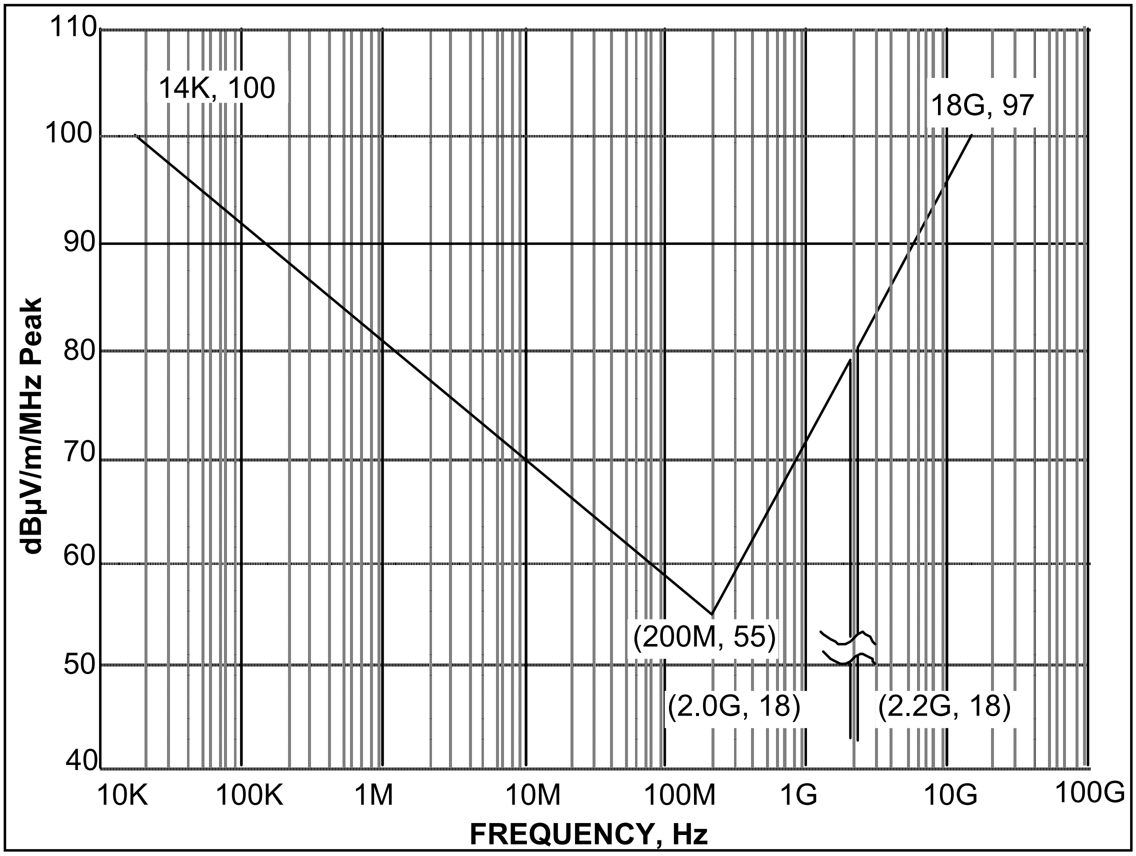


Figure 4.3.2.5.5.2
RE02 Broadband Radiated Emission Limit

4.3.2.4.6.2 Radiated DC Magnetic Field Susceptibility

The component/instrument shall not exhibit any undesired response, malfunction or performance degradation beyond the tolerances allowed by its specification in the presence of the ambient magnetic field consisting of the earth's field (15 to 50 micro-Tesla), the fields generated by neighboring instruments (3 micro-Tesla maximum) and the field produced by the magnetic torquers of the spacecraft (1,000 micro-Tesla maximum).

4.3.2.4.7 Radiated Susceptibility, Electric Field (RS03)

The component/instrument shall not exhibit any undesirable response, malfunction or performance degradation beyond the tolerances allowed by its specification when it is subjected to the following radiated electric field strengths using the RS03 test method of MIL-STD-462:

- 2 V/m between 14 KHz to 2 GHz
- 10 V/m between 2 GHz to 18 GHz except at the following spacecraft transmitter frequencies:
- 20 V/m at 2.2875 GHz ±2MHz
- 20 V/m at 8.2125 GHz ±187.5 MHz
- 20 V/m at 15.0034 GHz ±200 MHz

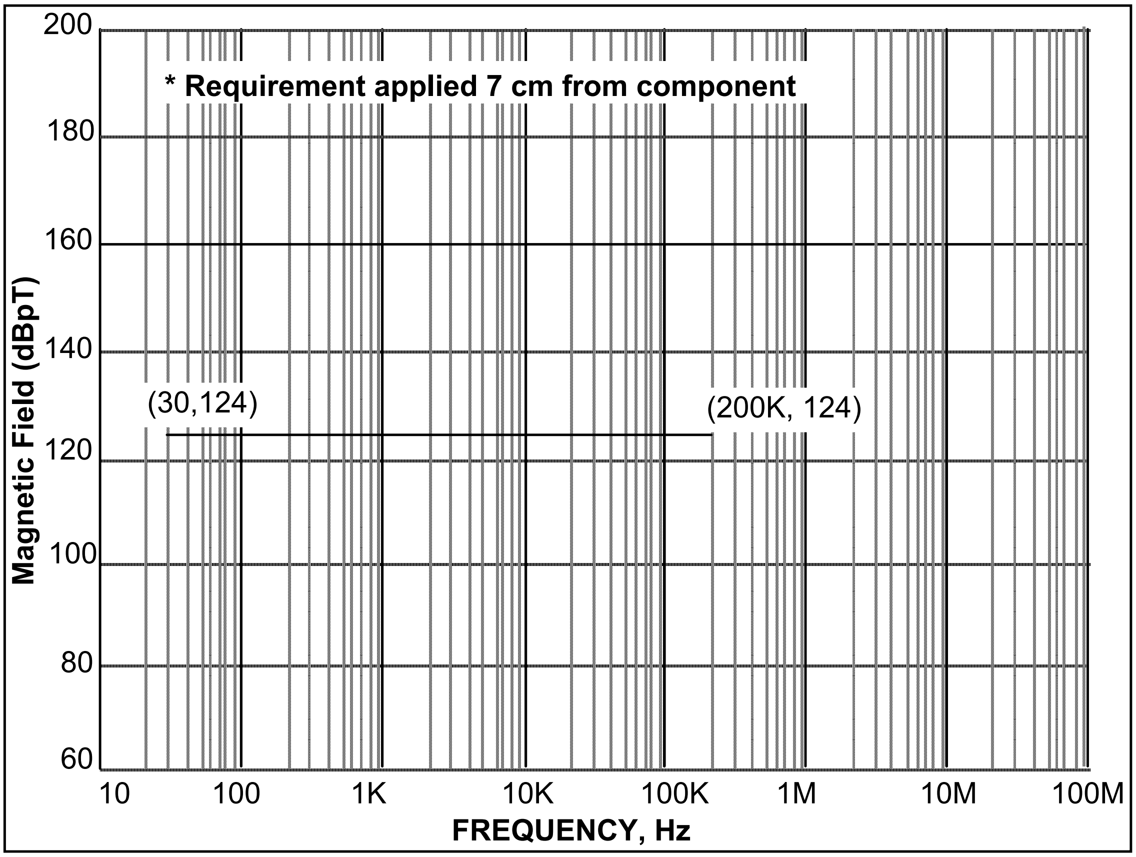


Figure 4.3.2.4.6.1
RS01 Radiated AC Magnetic Field Susceptibility Limit

4.3.2.5 Thermal Balance Test

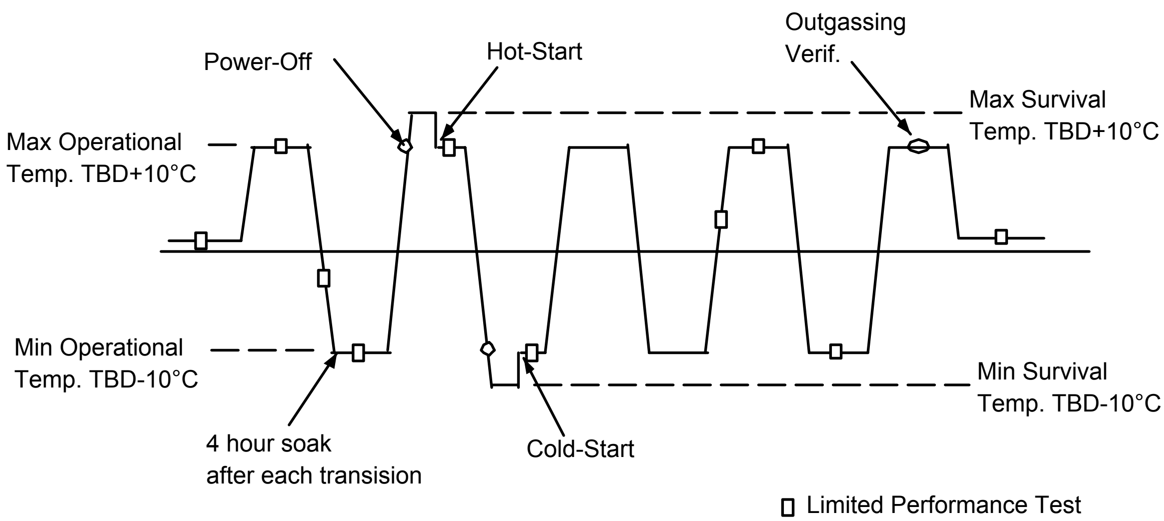
The validity of the Instrument thermal design and Thermal Model shall be demonstrated by subjecting the Instrument to a thermal balance test. During this test the instrument shall be configured and operating in its "Operational Mode" which has the survival heaters operational for the entire duration of the test. This test shall occur at 3 (TBV) temperatures and may be combined with the Thermal-Vacuum Test.

4.3.2.6 Thermal-Vacuum Testing

The Instrument shall be subjected to eight cycles within a thermal-vacuum test. Four of these cycles shall be performed at the subsystem level as defined in section 4.2.4.1.3.3 and four shall be performed at the instrument level as defined below.

4.3.2.6.1 Instrument Level Thermal-Vacuum Test

The instrument shall be subjected to a 4 1/2 cycle thermal-vacuum test. The test shall commence with a "hot" cycle and shall conclude with a "hot" cycle. The Thermal-Vacuum test requirements are defined in the Draft MAR (GSFC 424-11-13-01) dated September 1996 (TBR). The test environment is depicted in Figure 4.3.2.6.1. The pressure shall be $5x10^{-5}$ Torr ($6.64x10^{-3}$ Pascal's) or less. During the thermal-vacuum test, the instrument shall be configured and operating in its "Operational Mode" except during periods of Limited Performance Testing and during Hot and Cold survival temperatures. The survival heaters shall be operational for the entire duration of the Thermal-Vacuum Test. The cycling test environment shall be initiated by a high temperature soak. Each cycle shall include a 4-hour soak at the high and low-temperature levels. Limited Performance tests shall be conducted at the extremes of the operating temperature range during the first and last thermal cycles, following the Hot and Cold starts, and during one Hot-to-Cold and one Cold-to-Hot transition. The transition between extreme temperature levels shall be made at a maximum rate of 20.0 deg. C per hour. The last three cycles shall be failure free.



Notes for profile:

A) Maintain plateaus for 4 hours minimum

B) Maximum rate of change between plateaus shall be nominally ±20°C/hour.

C) Limited performance testing shall be run during identified transitions

D) Instrument shall be configured into its operational State during T-Vac testing and outputs monitored except during periods of Limited Performance testing and during Hot and Cold survival temperatures

E) Pressure shall be Š 5x10^{-5} Torr (6.64x10^{-3} Pascals)

Figure 4.3.2.6.1
Instrument Level Thermal-Vacuum Test

4.3.2.7 Instrument Level Outgassing Test

Verification of the Outgassing of Materials and Subsystems requirement defined in section 3.12.1.2 of the ITS shall occur at Instrument level by Test. This verification shall be performed at vacuum with the Instrument at its highest operational temperature +10C. This verification shall be included in the last hot cycle of the Instrument Thermal-Vacuum testing as shown in Figure 4.3.2.6.1. Verifications shall be made to the levels defined in each SSD and may be performed either at the subsystem level or at individual unit levels. The

Instrument level Outgassing test shall incorporate a 15 Mhz Temperature controlled Quartz Crystal Microbalance (TQCM), with the crystal temperature held at -20°C as defined in paragraph 3.12.1.2 of the ITS.

4.3.2.8 Instrument Level Failure-free Operation

The verification of failure-free operation at the instrument level shall be in accordance with the MAR paragraph 3.3.5. The verification of this requirement shall occur as part of the Instrument Radiometric Calibration process in Oxford.